TOWARDS ZERO

MILIEU DESIGN SOLUTION (IT PARK)

THESIS REPORT

Submitted by

UDHAYA SHANKAR

In partial fulfillment for the degree of

BACHELOR OF ARCHITECTURE

RVS SCHOOL OF ARCHITECTURE, COIMBATORE

ANNA UNIVERSITY | CHENNAI 600 025

May 2020

ANNA UNIVERSITY | CHENNAI 600 025

BONAFIDE CERTIFICATE

Certified that this project report **"TOWARDS ZERO | MILIEU DESIGN SOLUTION (IT PARK)"** is the bonafide work of **"UDHAYA SHANKAR"** who carried out the project work under my supervision.

Ar. SUDHA	Ar. PRABHAKARAN
HEAD OF DEPARTMENT	**GUIDE**
RVS SCHOOL OF ARCHITECTURE	RVS SCHOOL OF ARCHITECTURE
COIMBATORE	COIMBATORE

DECLARATION

I declare that this dissertation was carried out by me. It has not been previously submitted to this or any other Institution for the award of a degree of any other qualification.

Udhaya Shankar

(pudhai.udhai27@gmail.com)

PLAGIARISM CERTIFICATE

PLAGIARISMA

100% Unique

Total 1292 chars , 197 words, 8 unique sentence(s).

Results	Query	Domains (original links)
Unique	Building sectors should also show interest in moving Towards Zero	-
Unique	The concept of TOWARDS ZERO could be implemented and accepted, with the immediate future	-
Unique	Developing an understanding and an acceptance of sustainability in the practice of architecture is	-
Unique	The purpose of this project is to convey the concept Towards Zero, which is more	-
Unique	phase of construction and productive landscape which are crucial elements to minimize the negative impact	-
Unique	The intension was to design a sustainable office campus in Coimbatore, which will be evaluated	-
Unique	their environmental impact, recently the supreme court on 14-feb-2020 approves the use of double-sided printing	-
Unique	The Towards Zero: Milieu Design Solution (IT Park) demonstrates high standard of sustainable development using	-

Developing an understanding and an acceptance of sustainability in the practice of architecture is a crucial step towards restoring global resilience and future proofing the quality of human life.The purpose of this project is to convey the concept Towards Zero, which is more efficient than Net Zero to tackle the climate crisis. Until now Net Zero buildings does not consider the embodied carbon emission during the phase of construction and productive landscape which are crucial elements to minimize the negative impact to the environment.The intension was to design a sustainable office campus in Coimbatore, which will be evaluated under LEED ZERO program for ensuring the efficiency of Towards Zero concept. It's really happy to see various organizations and departments are taking initiative to reduce their environmental impact, recently the supreme court on 14-feb-2020 approves the use of double-sided printing for filings in environmental interest. Building sectors should also show interest in moving Towards Zero.The Towards Zero: Milieu Design Solution (IT Park) demonstrates high standard of sustainable development using IT Park as a medium to convey the concept Towards Zero. The concept of TOWARDS ZERO could be implemented and accepted, with the immediate future.

ACKNOWLEDGEMENT

I take this opportunity to offer my sincere gratitude to all who helped me in the preparation of this dissertation.

First and foremost, I would like to thank my thesis guide, Ar. Prabakaran for all the support and guidance he has offered me throughout the compilation of my thesis. Your strong advice and positive outlook have helped me move forward.

Thanks to Ar. Manikandan, Ar. Saravana Kumar, Ar. Sudha, Ar. Vetrivel Kannan for their invaluable comments which placed me on correct path.

Thanks to Himanshu, IGBC executive officer, who helped me in supplying the information and checklist.

Thanks to NZEB initiative by USAID, Ministry of power and EDS global, for all the information during the case studies.

Even though my friends don’t like thanking between us, I would like to thank them for their support and motivation.

Last, but no means not least my dear parents who allowed me to start a career on architecture five years ago regardless of the trend and continuing that support and guidance throughout my college education.

ABSTRACT

Developing an understanding and an acceptance of sustainability in the practice of architecture is a crucial step towards restoring global resilience and future proofing the quality of human life.

The purpose of this project is to convey the concept Towards Zero, which is more efficient than Net Zero to tackle the climate crisis. Until now Net Zero buildings does not consider the embodied carbon emission during the phase of construction and productive landscape which are crucial elements to minimize the negative impact to the environment.

The intension was to design a sustainable office campus in Coimbatore, which will be evaluated under LEED ZERO program for ensuring the efficiency of Towards Zero concept. It's really happy to see various organizations and departments are taking initiative to reduce their environmental impact, recently the supreme court on 14-feb-2020 approves the use of double-sided printing for filings in environmental interest. Building sectors should also show interest in moving Towards Zero.

The Towards Zero: Milieu Design Solution (IT Park) demonstrates high standard of sustainable development using IT Park as a medium to convey the concept Towards Zero. The concept of TOWARDS ZERO could be implemented and accepted, with the immediate future.

CONTENT

LIST OF ILLUSTRATIONS

LIST OF TABLES

LIST OF ABBREVATIONS

AHU	AIR HANDLING UNIT
ASHRAE	THE AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS
DF	DAYLIGHT FACTOR
EAC	ENERGY ATTRIBUTE CERTIFICATE
ECBC	ENERGY CONSERVATION BUILDING CODE
EPW	ENERGY PLUS WEATHER DATA
EQ	ENVIRONMENTAL QUALITY
EV	ELECTRIC VEHICLE
FSI	FLOOR SPACE INDEX
GBC	GREEN BUILDING COUNCIL
GHG	GREEN HOUSE GAS
HVAC	HEATING VENTILATION AND AIR CONDITIONING
IGBC	INDIAN GREEN BUILDING COUNCIL
IPCC	INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
ISHRAE	THE INDIAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS
LCA	LIFE CYCLE ASSESMENT
LCI	LIFE CYCLE INVENTORY
LEED	LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN
NBC	NATIONAL BUILDING CODE
NZEB	NET ZERO ENERGY BUILDING
OSR	OPEN SPACE RESERVATION
SDB	SOFTWARE DEVELOPMENT BLOCK
SEZ	SPECIAL ECONOMIC ZONE
SRI	SOLAR REFLECTIVE INDEX
TERI	THE ENERGY AND RESEARCH INSTITUTE
TNCDBR	TAMILNADU COMBINED DEVELOPMENT AND BUILDING RULES
UDI	USEFUL DAYLIGHT ILLUMINANCE

UNFCCC	UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE
USGBC	U.S GREEN BUILDING COUNCIL
VLT	VISUAL LIGHT TRANSMITTANCE
WWR	WINDOW WALL RATIO

INTRODUCTION

INTRODUCTION

Right from the industrial revolution during the mid-18th century there has been a truly incredible technological and economic advancements across the globe and paves the way for modern era. Modern industrial societies are deeply dependent on economic and technological processes with historically unprecedented material and energy demand. Unfortunately, fossil fuels became key and primary source of energy for the modern industrial society. Inhabitants of modern world at present now understands that the rapid and unprecedented burning of fossil fuels is driving anthropogenic climatic change.

PROBLEM OF CLIMATE CHANGE

The Intergovernmental Panel on Climate Change (IPCC) report – 2018 has warned of disastrous consequences if current trends of global warming are not reversed immediately. The report says that the impact of a 1.5°C increase in global temperatures will “affect the populations through food insecurity, higher food price, income losses, lost livelihood opportunities, adverse health impacts and population displacements”. The major means of impact will be through sea level rise and deadly heat waves, more vulnerable than 2015, which killed thousands of lives in India and Pakistan. While the report also says that it is not too late to reverse rising temperatures and minimize some the adverse effect.

The major causes of the effects are due to increase in greenhouse gases. Various organization around the globe are doing their part in initiating resilient models and approaches towards a better future, decreasing the carbon levels and keeping a check at the greenhouse gas emissions.

BUILDINGS AND CLIMATE CHANGE

Number of organizations working on climate change points out GHG emissions from the burning of fossil fuels as the root cause

of anthropogenic climatic change. Built environment has a major contribution role in GHG emission.

CSTEP analysis shows that 68 percentage of India's GHG emissions come from energy sector and as per IPCC report – 2014, buildings accounted for 32% of total global final energy use and 19% of energy related GHG emissions. In that commercial sectors accounts for most of the energy and GHG emission from buildings, next to residential sector.

Building science organization and researchers such as architecture 2030 assert that the problem and the solution to climate change is buildings.

BUILDINGS AND SOLUTION TO CLIMATE CHANGE

It is also a primary subject to be discussed regarding the solution for climate change through buildings. The most common cited emission reduction solution related to built environment are by technological or conservation-based approaches. The technological approach focuses on to generate new source of clean energy and the conservation-based approach focuses on combing traditional ways of building with new (energy-efficient) technology in order to dramatically reduce built environment emission. At this point rises the concept of Net Zero approach to reduce overall built environment emissions. Although Net Zero way of approach has a significant impact on reduction of emission by built environment, the consideration taken up by Net Zero initiatives across the globe is not sufficient for current context and this why a new concept of Towards Zero is essential for the built environment to have a great impact in reduction of GHG emission by built environment. This is discussed further in upcoming chapters.

INTRODUCTION

Towards Zero encourages a holistic approach for buildings and places to enhance the health and well-being of building occupants, the earth and all living creatures. This work is even more important in light of the Intergovernmental Panel on Climate Change (IPCC) report October 2018, describing the impacts of global warming of 1.5°C to 2°C above pre-industrial levels on environmental, human health and economic systems. In sum, climate change requires fundamental shifts to the structure and consumption habits of human society as well as adaptive and integrated carbon reduction and sustainable development strategies deployed at all scales. The built environment plays a critical role in accelerating the transition to a low carbon society and enhancing the health of natural and human ecosystems. Towards Zero conceptual framework consist of five major categories to be achieved they are as follows

Carbon Balance:

Carbon neutrality or carbon balance, refers to achieving a balance of zero or negative carbon dioxide equivalent (Co_2e) for the past year. This can be evaluated from a simple equation

Carbon Balance = Total Carbon Caused – Total Carbon Avoided

If the balance is ≤ 0, then the project is in compliance with Towards Zero Carbon Balance

Whereas carbon caused includes energy consumption, transportation and embodied carbon. For now, renewable energy generated and used on site is allowed to keep the value as zero, from 2030 onwards this value will be considered for calculation with respective to their carbon dioxide equivalent, in order to promote the use of renewable energy this allowance is valid till 2030. In transportation, value for walk, bike... is considered as zero and for other mode of transportation it’s been calculated based on vehicle and no of trips, for visitors you can consider as one-way

trip. Embodied carbon plays an important role in construction industry and this value is been calculated based on the volume of building material used, density of building material and embodied carbon emission of that material.

Towards Zero recommends to calculate the values during the design stage, so that it's easier to tackle the issues and choose right material for the project.

Refer appendix-1 for mode of calculation and equations used to determine the value.

Energy Balance:

A net zero energy or energy balance means that total amount of energy used by the building on an annual basis is equal to that of renewable energy generated on-site or procured off-site. This can be evaluated from a simple equation

Source energy balance = Total energy consumed – Total energy Generated on-site or Procured off-site

If the balance is ≤ 0, then the project is in compliance with Towards Zero Energy Balance

Here environmental benefits of all renewable energy generation or procured must be retained by the project. Energy consumed includes all form of energy consumed by the project and energy generated includes renewable energy generated and used on site, on site generated electricity exported to the grid and offsite renewable energy added to an electric grid.

Towards Zero recommends to calculate the energy potential during the design stage, so that it's easier to tackle the issues and adapt right strategies for the project.

Refer appendix-2 for mode of calculation and equations used to determine the value.

Water Balance:

Water is the main constituent of earths hydrosphere and the fluids of most living organisms; it is vital for all known forms of life. Water balance means that total portable water consumed to be balanced through any other alternative water used and/ or water returned. This can be evaluated from a simple equation

Water Balance = Total Potable Water Consumed – (Total Alternative Water Used + Water Returned to Original Source)

If the balance is ≤ 0, then the project is in compliance with Towards Zero Water Balance

During the design phase you can consider the value for potable water consumed by the project with relevant to the national standards. For post occupancy you have to consider the value based on water metering installed with relevant to annual documents. Whereas alternative water sources include offsite water sources from reclaimed water delivered from municipality... and onsite water sources from captured rainwater, stormwater runoff, grey water reuse... water returned includes the water collected, onsite treated wastewater and returned to original water source.

Towards Zero recommends to calculate the water demand during the design stage, so that it’s easier to reduce the potable water demand through various strategies like efficient fixtures, treated grey water for landscaping and flushing...

Refer appendix-3 for mode of calculation and equations used to determine the value.

Zero Waste Discharge:

Zero waste discharge is a goal that is ethical, economical, efficient and visionary, to guide people in changing their lifestyle and practices to emulate sustainable natural cycles, where all discarded materials are designed to become resources for others to use. It highly recommended to reduce the waste entering the site, i.e. products wrapped with cardboards, plastic covers... might

be waste for some people, which can be just throwed away, this can be reduced through choosing right vendor or making an agreement with vendors to get back those covers after delivery or by making use of those materials.

For evaluating this its recommended to obtain platinum rating in TRUE Zero Waste rating system.

Productive landscape:

A combination of concern over healthier diets and embodied carbon over the food products lets to the inclusion of productive landscape in current scenario. Let me tell you a fact, there is 22% of reduction in carbon footprint from the food products brought locally than imported one. Although 60% of the embodied carbon associated with food products are from insecticides, pesticides and machineries used in farming. To combat these factors Towards Zero recommends to go for productive landscaping which contributes to at least 40% of the daily needs.

Some of the recommended consideration are as follows:

+ High preference for native species
+ Prefer endangered species over the locality
+ Prefer drought tolerant species
+ Prefer productive species for at least 40% of the total species
+ At least 10 different species to be planted
+ Any hazardous species on site to be removed

NET ZERO VS TOWARDS ZERO

In theoretical aspects Towards Zero might be similar to Net Zero but, the actual case is – it’s not. When we dig deeper into the considerations of Net Zero at current scenario, we end up seeing that all those considerations are only based on the operational activities rather than considering the whole building from the date of execution. In simple words this is said to be the overall differentiation between them.

Now let’s look into the major changes, under carbon balance category Towards Zero considers embodied carbon associated with the construction and from 2030 onwards carbon emission from renewable energy generated and used on site will be considered. Have added a new category of productive landscaping since, concern over the healthier diets and embodied carbon associated with food products also plays a vital role in current scenario.

CRITICAL ROLE OVER 2030

Towards Zero aims to play a major role in tackling the adverse effect due to climate change over 2030. All the actions recommended by Towards Zero are in response to act within 10 years of duration for cutting of the major share of GHG emission in a short period of time. It is essential to make change in people’s way of life to have an effective outcome of it, as stated in the recommendations by Towards Zero.

Towards Zero calls on business, organization, cities, states and regions to take urgent, courageous and immediate climate action towards decarbonizing the built environment, along with the Towards Zero concept to avoid the worse in upcoming years.

By setting ambitious ‘Towards Zero’ target, aims to maximize the chances of limiting global warming to below 2 degrees, and ideally below 1.5 degrees, by drastically reducing emissions from buildings.

LITERATURE STUDY

Significant relevant literature has been used regarding the state of knowledge and opinion about the proposed concept, covering a wide cross section of resources.

Apple park:

Apple park (also referred to as apple campus 2) is of 176 acres, which will accommodate 12,000 employees, located on Cupertino, California, US. It belongs to warm-summer Mediterranean climate, the main building is of 2.8 million sq. ft built up area. Designed by Foster + Partners with worlds largest panels of curved glass.

Apple park is LEED v3 Platinum certified and achieves net-zero energy from multiple sources of renewable energy, including 17 MW rooftop solar plant and 4 MW biogas fuel cell. During the period of low occupancy, the clean energy generated is provided to the grid.

Landscaping incorporates both young and mature plants, native drought tolerant plants which minimizes the water consumption. On a whole there are 7034 trees including 6100 proposed trees, here the total permeable area alone accounts for 101.7 acres.

Apple park provides 1000 bicycles to its employees to move across the campus with parking spaces at various points. There are 300 EV charging points installed over the parking spaces to promote the electric vehicles.

This campus is said to be the worlds largest naturally ventilated buildings for over nine months in a year without the need of heating and air conditioning.

Main building adopts open planning with entrance core at regular interval for easy access. There is an air and light shelf (18 ft) at the center of the floor plate running throughout the plan. Air shaft at the center of the floor plate helps in achieving the thermal comfort with the stack effect. Hollow core slab helps in reducing the heat gain into the building by increasing the time lag.

Apple park uses only 3% of portable water and the rest are recycled water obtained from Sunnyvale water pollution control center. It achieves a waste diversion rate of 78% through multiple alternatives such as reuse, recycling.

Figure 1, Apple park-Cupertino (visualization)

Pixel:

Pixel is of 3.95 acres, located on Melbourne, Victoria, Australia. It belongs to temperate climate; the total built up area is of 12,230 Sq. ft. Designed by Studio 505 and said to be the Australia's first carbon neutral office building.

Worlds highest LEED rated building with 105/110 points under LEED v3, earned addition five points in innovation for achieving carbon neutrality, vacuum toilet system, anaerobic digestion system and reduced parking space.

Open office plan is been provided so that employees feel a sense of community and enjoy natural lighting and exterior view. Colorful panelized façade is not about aesthetics but also to allow maximum daylighting, shade, glare free workspace and view.

Energy efficient design, which includes the use of pixelated shade screen façade, double glazed windows, daylighting and natural

ventilation minimize the need for energy. Gas was chosen to tackle the energy demand for heating and cooling than the traditional brown coal powered grid electricity since it is six times greater in carbon intensity.

Both the reduction in energy demand and carbon intensity allowed for relatively small amount of renewable energy sources to be installed on site to achieve a net balance of carbon emissions. It utilizes three wind turbines, fixed and tracking photovoltaic arrays for its energy needs, with surplus being fed back into the electric grid. When netted on annual basis, pixel does not produce any carbon emission due to its operational energy use. In addition, over its 50 years life cycle, it recoups all the embodied carbon emissions generated during its construction through surplus on-site renewable energy it generates and feeds back into the grid.

Radiant cooling system is been incorporated with gas fired ammonia chiller cools the water needed to cool the entire slab. Pixel façade includes smart window technology that automatically opens the windows of the façade on cool nights to enable night purge. 100% fresh air is circulated throughout the building via floor spaces and is controlled via floor vents at each workstation.

Massive amount of recycled materials is used during construction and have developed a new concrete called pixelcrete, which almost halved the embodied carbon than the traditional concrete mix. Water demand reduction is achieved though various measures including vacuum toilets designed to reduce the water consumption.

Figure 2, Pixel-Melbourne (visualization)

LIVE STUDY

Significant relevant live study was undertaken regarding the state of knowledge and opinion about the proposed concept, covering a wide cross section of resources.

Infosys:

Infosys - Hyderabad is of 450 acres, which accommodate 27,000 employees (currently). It belongs to composite climate and the SDB-1 is of 2.33 million sq. ft built up area. Designed by RSP architects with phase-2 under construction.

Here the buildings are oriented in such away that longer facades facing N-S direction and shorter facades facing E-W direction, so that direct solar radiation hitting the building façade will be on shorter façade which has minimum openings. The window wall ratio is less than 30% which reduces the heat gain inside the building. Office cabins and open workstation are placed in such a way that it receives direct daylighting. Conference rooms are

placed near the shaded area, due to its function and obtains indirect daylighting. Service pockets are placed at the center of each wing for easy accessibility. Floor plate is restricted to 18m width, to get sufficient daylighting inside the space.

SDB-1 has radiant cooling on one wing and conventional cooling on another wing, here the wing with radiant cooling is 30% more efficient than the conventional HVAC system. The quantity of air required is 1/5 of what is required for conventional side of the building. At the same time the air quality on the radiant side is much higher because there is no recirculation needed, so that contamination is reduced.

Windows are split into upper panel, which lets in natural light and lower panel, which provides outside view. Windows are completely shaded with horizontal and vertical fins to prevent glare; this ensures entire office to be daylit without any glare during the working hours. A light shelf is installed which reflects the incoming sunlight onto the ceiling and distributes deeper into the space.

On a whole 18% of the total building materials used in the project is made out of recycled materials and 38% of the building materials are regionally manufactured. Harvested rainwater is utilized for vegetation purpose, solar plant is grid connected with net banking system which generates 42,000 units/ day. Here only the plastic, hazardous and e-waste are sent outside the campus to a proper treatment plant. All other waste is treated and utilized inside the campus such that organic waste and plant debris are treated and used as manure for the landscapes.

Figure 3, Infosys-Hyderabad (visualization)

Wipro:

Wipro - Bengaluru is of 46.98 acres, located at kodathi, Bengaluru, India. It belongs to temperate climate and the main building is of 2.37 million sq. ft built up area. Designed by venkataramanan associates with phase-2 under construction.

In this campus first phase is of four blocks which was evaluated for IGBC New Building rating system and satisfies IGBC platinum rating, the second phase is of three block which are currently under construction.

Here more than 50% of the site area, including the development footprint is restored by designing vegetated spaces over built structures and on ground. The overall water consumption is 28% lesser than the baseline criteria recommended by NBC. Materials used in construction are certified under green building materials by IGBC green pro. Waste collected from all pockets of the campus is been segregated under common waste segregation room and the segregated organic waste are used as manure for landscaping. Most of the trees present over the site were been preserved/

transplanted inside the campus except hazardous species which were removed and 1651 new trees were been planted. Two types of irrigation system were been used drip and sprinkler.

All the office block receives daylighting for 75% of regularly occupied spaces and 83.59% of regularly occupied spaces receive direct line of sight. Podium 1&2 of block 3&4 are utilized for employees parking space with electric vehicle charging point for 5% of the parking space. Podium 3&4 of block 3&4 are utilized for kitchen and dinning space for the whole campus.

To minimize the heat gain into the space building is been oriented in such a way that longer facades facing N-S direction and shorter facades facing E-W direction. Conference and meeting rooms are placed at low daylighted area due to its function. Service pockets are placed at the center each wing for easy accessibility. Co_2 monitors are placed on every zone of work space to monitor the air quality and to make sure of sufficient air quality is supplied inside the workspace. All the roof surfaces are coated with higher solar reflective index (SRI) material to reduce the heat island effect.

The window wall ratio is less than 40% which reduces the heat gain inside the building, double glazing windows were been used with argon filling to minimize the heat gain into the space. The shading devices used over here are made of wooden planks with 20mm thickness and 100mm width. Renewable energy generated on site through rooftop solar power is 679,908 Kwh/ Year. The solar plant is grid connected with net banking system.

Figure 4, Wipro-Bengaluru (visualization)

INFERENCE

Form the literature and live study, inference is been derived out which would be helpful during the design phase of this project.

Open office is ideal to get natural daylighting and ventilation, as well as exterior view, this would increase the productivity and reduces the sick building syndrome. From the study thin buildings (within 18m width) are receiving daylighting throughout the space and the ideal orientation is such that longer façade facing N-S direction, such that it receives lesser heat gain into the space than the one with E-W orientation. Service core should be within 10% of the total buildup area.

The radiant cooling system is more efficient than the conventional cooling systems which reduces energy demand for air conditioning and gives high indoor air quality and the window wall ratio shall be within 40% as stated by ECBC. Building materials should be selected based on the u-value as per the climatic condition and fire exit staircase are to be provided in accordance to the national standards, for India its National Building Code (NBC). Minimize the opening over E-W direction so that direct solar radiation hitting the building will not have adverse effect of heat gain into the space. Any other passive strategies for achieving thermal comfort can be implemented such as night purge, stack effect, natural ventilation...

RESOURCE USE

Its essential to talk about the Brundtland report, since this report made a major impact about climate change across nations in 1987 and said to be the document which coined and defined the meaning of ‘sustainable development’. This report talks more on the resource use, which is crucial for a sustainable way of development and even the green building rating system across the world also gives more importance to the material and resources since resource use plays a major role in sustainable development.

“sustainable development is development that meets the needs of the present without compromising the ability of future generation to meet their own needs”

-Brundtland report 1987

This talks about the careful utilization of resource is essential to meet the need of present, here in our project resources/ materials used are chosen based on the regional priority, recycled content and material in response to building performance program of the project. Follow are major materials used in the project:

MATERIAL USED			RECYCLED CONTENT		
DESCRIPTION OF MATERIAL	MANUFACTURER/ VENDOR	PRODUCT/ MODEL NAME/ NUMBER	POST CONSUMER (%)	PRE CONSUMER (%)	REGIONAL MATERIALS
CEMENT	DALMIA CEMENT	DALMIA PPC	35	25	100
ECO SAND (CEMENT INDUSTRY WASTE)	ACC CEMENT	ECO SAND (MANUFACTURED SAND)		100	100
FLY-ASH BRICKS	CR AND ASSOCIATES	FLY-ASH BRICK		45	100
AAC BLOCKS	AEROCON	AEROCON AAC BLOCKS		65	100
STRUCTURAL STEEL TMT	AGNI	AGNI TMT	25		100
BLUE METAL 75MM/ 50MM/ 20MM	SENTHIL MURUGAN BLUE METAL				100
STRUCTURAL CONCRETE RMC	PR READYMIX	READY MIX CONCRETE		25	100
FOAM CONCRETE FOR ROOF	CUBE READYMIX CONCRETE	FOAM CONCRETE		50	100
WALLCARE PUTTY	GREEN INDIA				100
METAL FAÇADE FRAMES AND GRILLS	FABRICATION WORK	GRILL AND FRAMING WORKS	25		100
GLASS (FACADES)	SAINT GOBAIN	SCG GRAPHITE ST 136	6	12	100
GYPSUM BOARDS	SAINT GOBAIN	GYPROC	3.8		100
FRP DOORS FOR TOILETS	KOVAI DOORS	FRP DOORS			100
CERAMIC FLOORING TILES	H&R JOHNSON (INDIA)	CERAMIC TILES		20	100
COOL ROOF ECO TILE	ROCO TILE	COOL TILE	15		100
COCO PEAT AND ORGANIC COMPOST GROWING MEDIUM	SP HORTIPLEX	COCO PEAT AND COMPOST	21	79	100

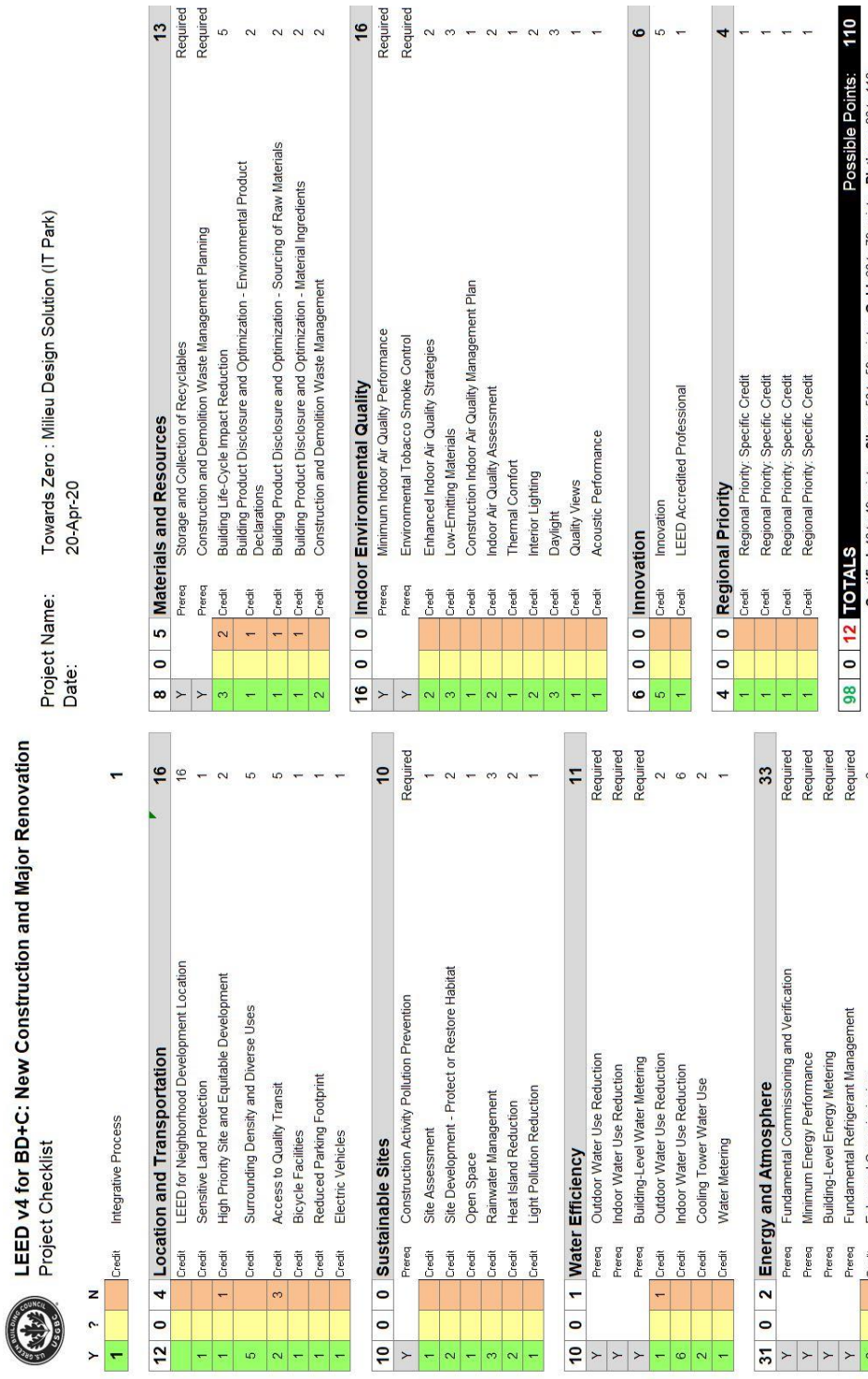
Table 1, Major materials used

WOOD USED			RECYCLED CONTENT	
DESCRIPTION OF MATERIAL	MANUFACTURER/ VENDOR	PRODUCT/ MODEL NAME/ NUMBER	RAPIDLY RENEWABLE (%)	FSC CERTIFICED WOOD (%)
MEDIUM DENSITY FIBRE BOARDS	FURNTECH	GREEN PANELMAX	85	85
PLYWOOD	FURNTECH	GREENPLY		100

Table 2, Woods used

LEED PRE-CERTIFICATE

As per the LEED Zero Program, any project for achieving LEED Zero needs to be platinum certified under the BD+C or O+M rating systems, here we have choose the BD+C : New Construction for the purpose of evaluation. In this we did a pre evaluation (before the design stage) which would state the possible, may be and not possible points, so that we can work more on that area during the design stage for achieving more credit points. At the end of design stage another evaluation is done and following credit point (Table 03) are as per the final evaluation which states that it is in compliance with LEED Platinum Certified.



LEED v4 for BD+C: New Construction and Major Renovation
Project Checklist

Project Name: Towards Zero : Milieu Design Solution (IT Park)
Date: 20-Apr-20

Y	?	N			
1			Credit	Integrative Process	1

12	0	4	**Location and Transportation**		16
			Credit	LEED for Neighborhood Development Location	16
			Credit	Sensitive Land Protection	1
1		1	Credit	High Priority Site and Equitable Development	2
			Credit	Surrounding Density and Diverse Uses	5
5					
2		3	Credit	Access to Quality Transit	5
1			Credit	Bicycle Facilities	1
1			Credit	Reduced Parking Footprint	1
1			Credit	Electric Vehicles	1

10	0	0	**Sustainable Sites**		10
Y			Prereq	Construction Activity Pollution Prevention	Required
1			Credit	Site Assessment	1
2			Credit	Site Development - Protect or Restore Habitat	2
1			Credit	Open Space	1
3			Credit	Rainwater Management	3
2			Credit	Heat Island Reduction	2
1			Credit	Light Pollution Reduction	1

10	0	1	**Water Efficiency**		11
Y			Prereq	Outdoor Water Use Reduction	Required
Y			Prereq	Indoor Water Use Reduction	Required
Y			Prereq	Building-Level Water Metering	Required
1		1	Credit	Outdoor Water Use Reduction	2
6			Credit	Indoor Water Use Reduction	6
2			Credit	Cooling Tower Water Use	2
1			Credit	Water Metering	1

31	0	2	**Energy and Atmosphere**		33
Y			Prereq	Fundamental Commissioning and Verification	Required
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Building-Level Energy Metering	Required
Y			Prereq	Fundamental Refrigerant Management	Required
6			Credit	Enhanced Commissioning	6
18			Credit	Optimize Energy Performance	18
1			Credit	Advanced Energy Metering	1
		2	Credit	Grid Harmonization	2
5			Credit	Renewable Energy	5
1			Credit	Enhanced Refrigerant Management	1

8	0	5	**Materials and Resources**		13
Y			Prereq	Storage and Collection of Recyclables	Required
Y			Prereq	Construction and Demolition Waste Management Planning	Required
3		2	Credit	Building Life-Cycle Impact Reduction	5
1		1	Credit	Building Product Disclosure and Optimization - Environmental Product Declarations	2
1		1	Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materials	2
1		1	Credit	Building Product Disclosure and Optimization - Material Ingredients	2
2			Credit	Construction and Demolition Waste Management	2

16	0	0	**Indoor Environmental Quality**		16
Y			Prereq	Minimum Indoor Air Quality Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control	Required
2			Credit	Enhanced Indoor Air Quality Strategies	2
3			Credit	Low-Emitting Materials	3
1			Credit	Construction Indoor Air Quality Management Plan	1
2			Credit	Indoor Air Quality Assessment	2
1			Credit	Thermal Comfort	1
2			Credit	Interior Lighting	2
3			Credit	Daylight	3
1			Credit	Quality Views	1
1			Credit	Acoustic Performance	1

6	0	0	**Innovation**		6
5			Credit	Innovation	5
1			Credit	LEED Accredited Professional	1

4	0	0	**Regional Priority**		4
1			Credit	Regional Priority: Specific Credit	1
1			Credit	Regional Priority: Specific Credit	1
1			Credit	Regional Priority: Specific Credit	1
1			Credit	Regional Priority: Specific Credit	1

98	0	12	**TOTALS**	Possible Points: 110

Certified: 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

Table 3, LEED v4.1 BD+C : New construction (Evaluation)

DESIGN BRIEF

A building program that includes clearly defined performance goals are essential for performance-based architecture. Accordingly, programing for the building being considered in this study, Towards Zero : Milieu Design Solution, began at the inception of the project with the establishment of requirements for site selection, functional and building performance programs. The site selection program was developed after analyzing the local climate and developing preliminary functional and building performance programs. It ensured that the site acquired for the project is adequate for achieving Towards Zero.

FUNCTIONAL PROGRAM

The functional program for Towards Zero : Milieu Design Solution are summarized as follows:

Primary Function

+ Create an innovative and beautiful campus that consolidates up to 15,000 employees in a single distinctive office building with supporting facilities. The purpose of consolidation within a single building set in a secure landscape is to promote shared creativity and collaboration.
+ Achieve security and privacy by eliminating any public access through the site and protecting the perimeters against trespassers.

Secondary Function

+ Maximize the provision of green space, and design this space in accordance with the climate and history of the area.
+ Provide on-site amenities for employees in order to promote employee’s health and well-being and reduce off-campus travel.
+ Provide on-site venue for corporate auditorium, fitness center, day care center and product exhibition space.

BUILDING PERFORMANCE PROGRAM

The purpose of the building performance program is to establish building performance goals as fundamental requirements that are on equal weightage to that of the functional program requirements of the project. The detailed building performance program for the project is included under Data Analysis. The overall building performance program goals for the project are summarized as follows:

+ Net Zero Energy
  - Balancing the energy demand (14,814.67 MWh/Yr.) through on-site renewable energy generation.
+ Carbon Neutrality
  - Carbon emission consideration includes the embodied carbon emission, which leads to careful selection of building materials and other design strategies.
+ Zero Water Balance
  - Balancing the portable water demand (180,000 Cu./m) through rainwater catchment.
+ Zero Waste Discharge
  - Ensuring of zero waste discharge to landfills.
+ Productive Landscape
  - Transforming the landscape for food production, minimal water consumption, native species and emotional & psychological response.

SITE DESCRIPTION

Site is located at saravanampatti (10km from Coimbatore city and 10km from airport) on NH-948 which connects Coimbatore and Bengaluru via sathy. All the basic amenities described by IGBC are available within 1km from the site main entry. Four major bus stops are available within 800m distance from the site which helps to encourage public transportation. The 110-acre site is roughly combination of square and rectangle at $3/4^{th}$ of the side, with its long axis oriented north – south. Site is gently sloped with higher level at SW corner of the site and lower level at NW corner of the

site. The site has excellent solar, precipitation and prevailing wind exposure that facilitate the wise use of these resources. There are many hazardous trees over the site which will be removed and replace with native species.

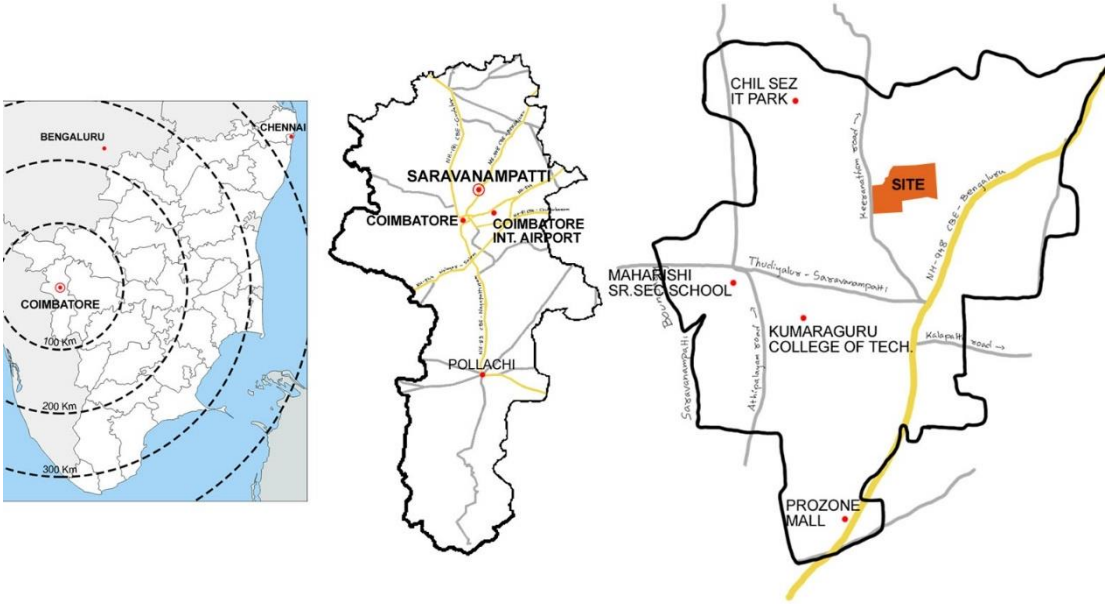


Figure 5, Site locator map, showing site relation to major scale

Figure 6, Site info with site images

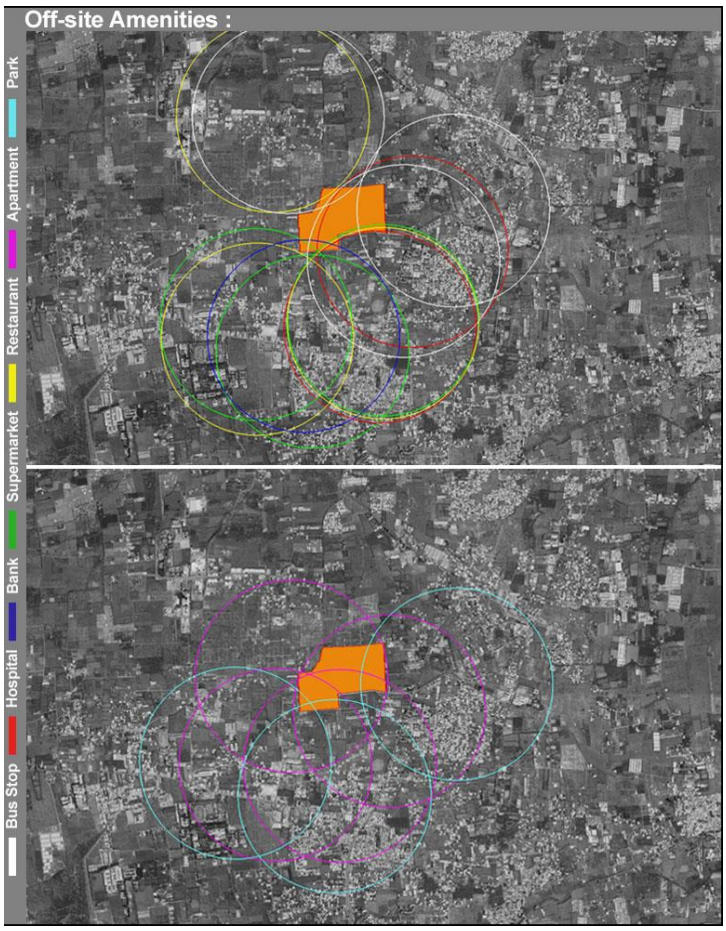


Figure 7, Offsite basic amenities

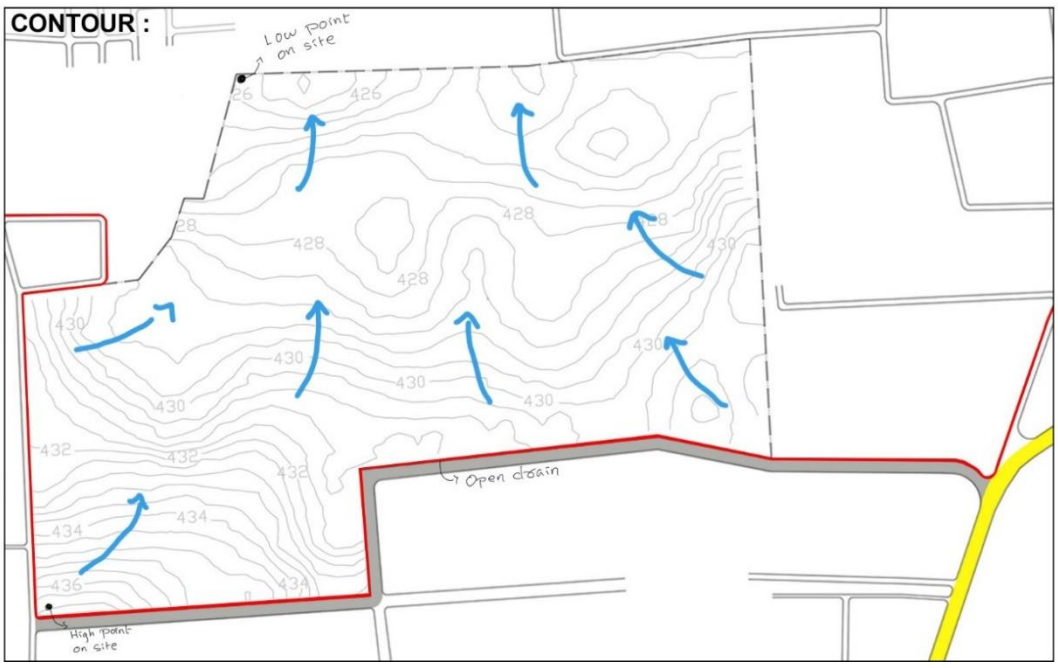


Figure 8, Site contour level

Site Climate

The goal of this project is to design and built a climate-responsive office space that over its lifecycle achieves Towards Zero. Obviously, an understanding of the climate is critical to the success of a project of this type. Coimbatore come under warm-humid climatic classification as per ECBC. There are many ways to describe a particular climate, but to a green building analyst, certain climatological aspects are fundamental. These fundamental aspects relate to temperature, relative humidity, cloud cover, prevailing wind. All the following climatic data are from Meteonorm 7.2 with climatic data Coimbatore/ Peelamedu (11.0°N, 77.1°E).

Average temperature of Coimbatore is 26.74°C, over heating periods were during the months of March, April and May so shading devices over these periods need to be taken into consideration. Relative humidity remains high throughout the year. Cloud cover is higher during the days of June, July and august so that solar power generation over these days will be slightly lesser than regular days. Prevailing winds are over North-East direction so we have to make utilize of this direction to achieve thermal comfort. We did a psychrometric chart analysis to predict passive techniques for achieve thermal comfort for maximum periods of the year and those techniques are as follows

+ Thermal mass
  - It’s the ability of a material to absorb and store heat energy, therefore materials with high thermal mass increases the time lag for heat penetration into the space.
+ Natural ventilation
  - In general, warm-humid regions require natural ventilation to achieve thermal comfort through a passive means. Here we are utilizing the NE prevailing wind for the same.
+ Indirect evaporative cooling
  - Indirect evaporative cooling works in such a way that it lowers the air temperature by causing water to evaporate.

Detailed chart values describing the climatic condition of the site are follows

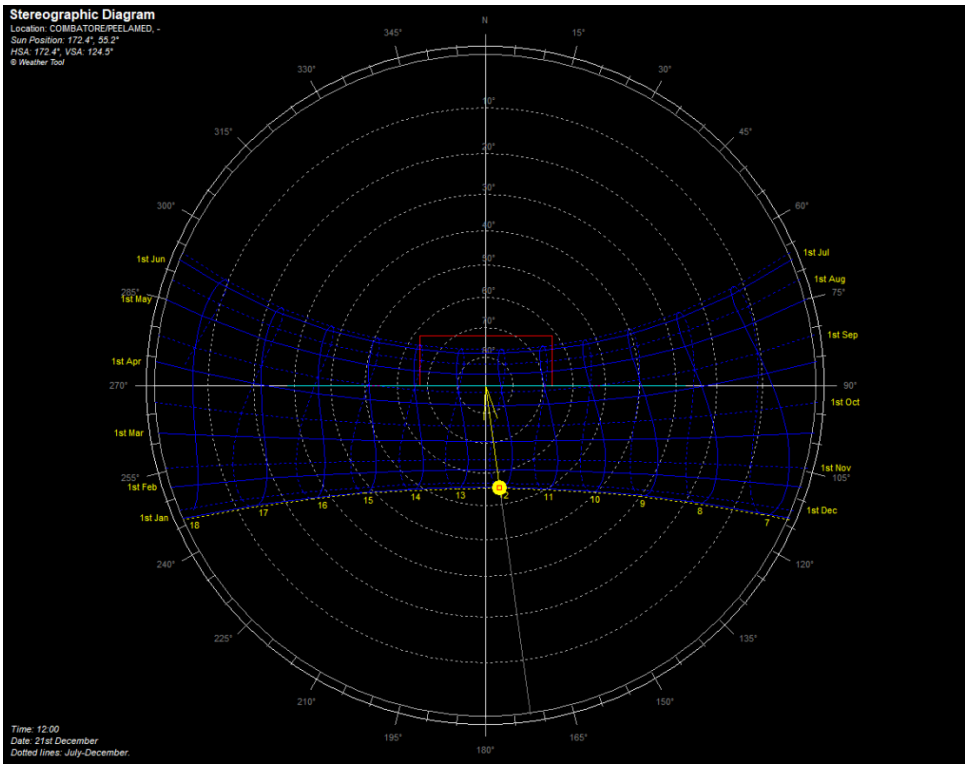


Figure 9, Stereographic diagram describing sun path

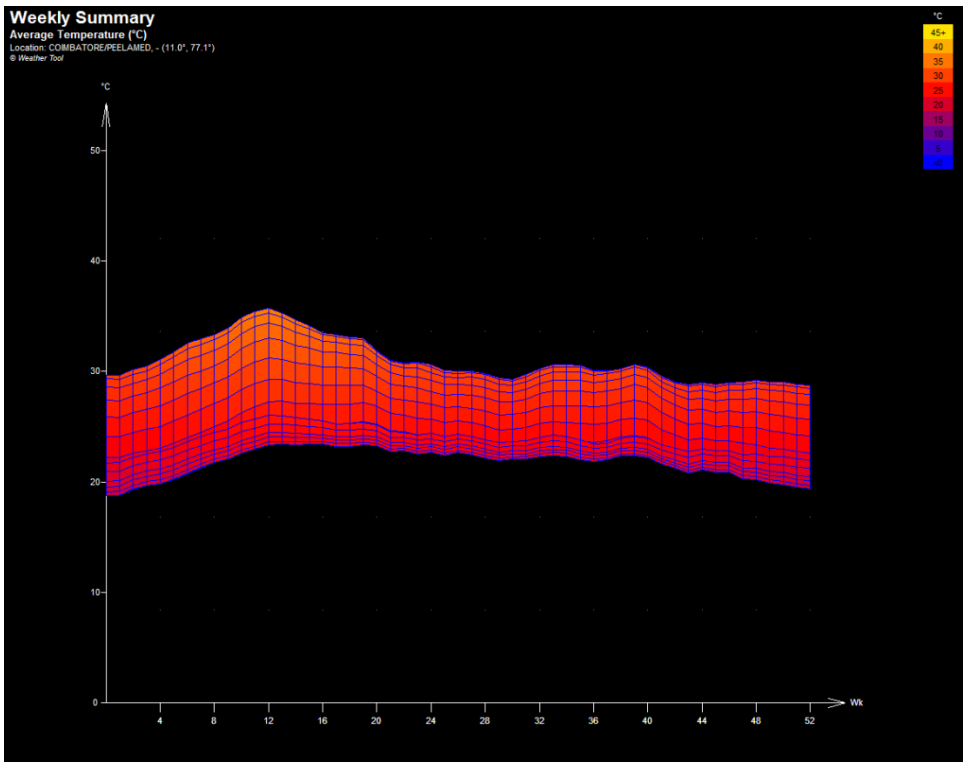


Figure 10, Average temperature (°C)

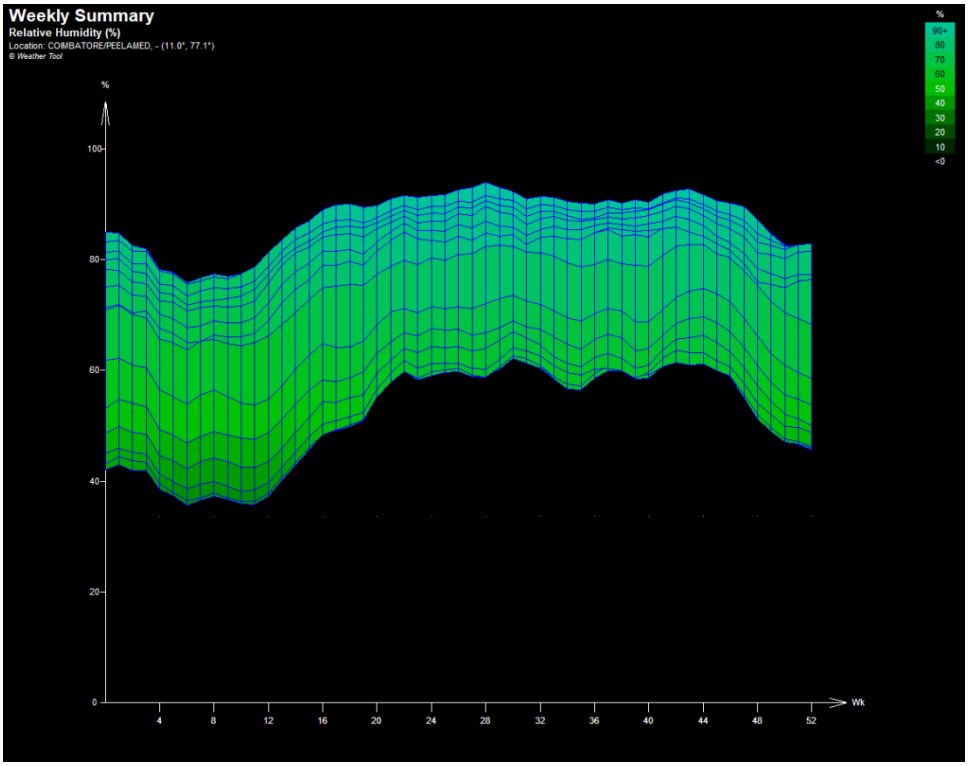


Figure 11, Average relative humidity (%)

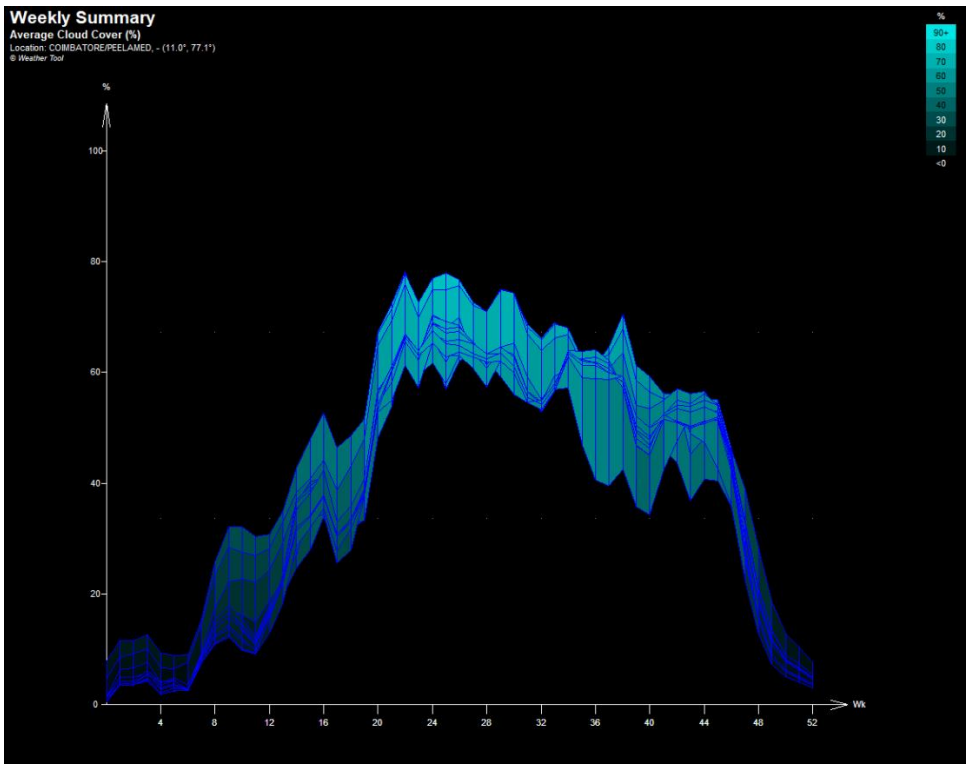


Figure 12, Average cloud cover (%)

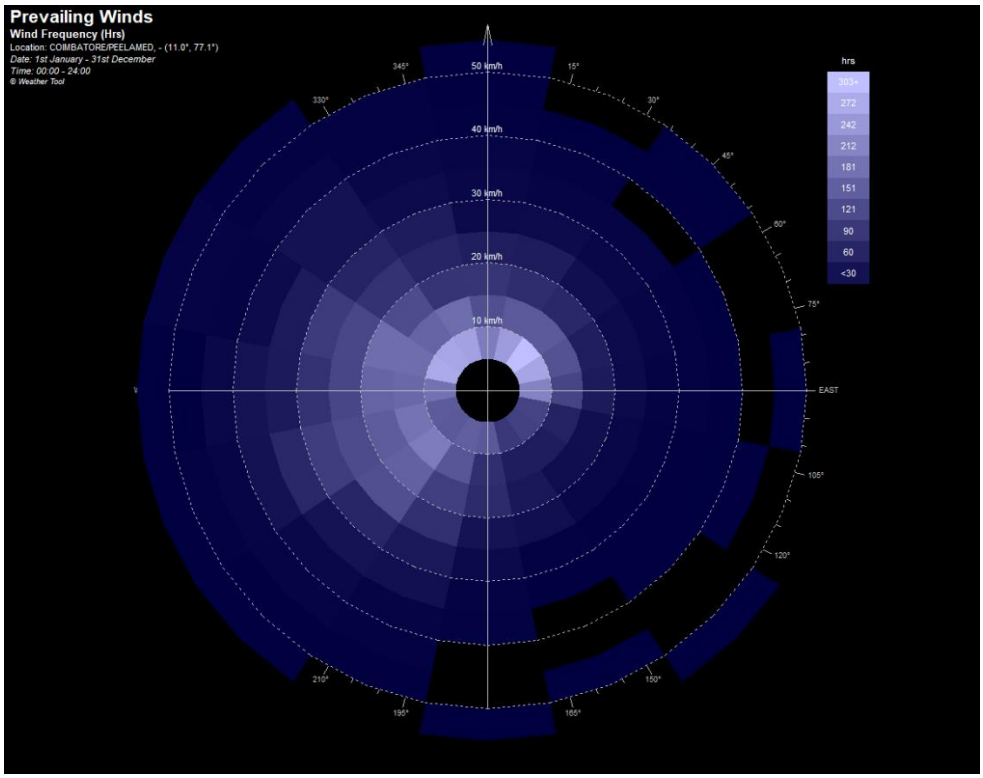


Figure 13, Prevailing wind direction with wind speed

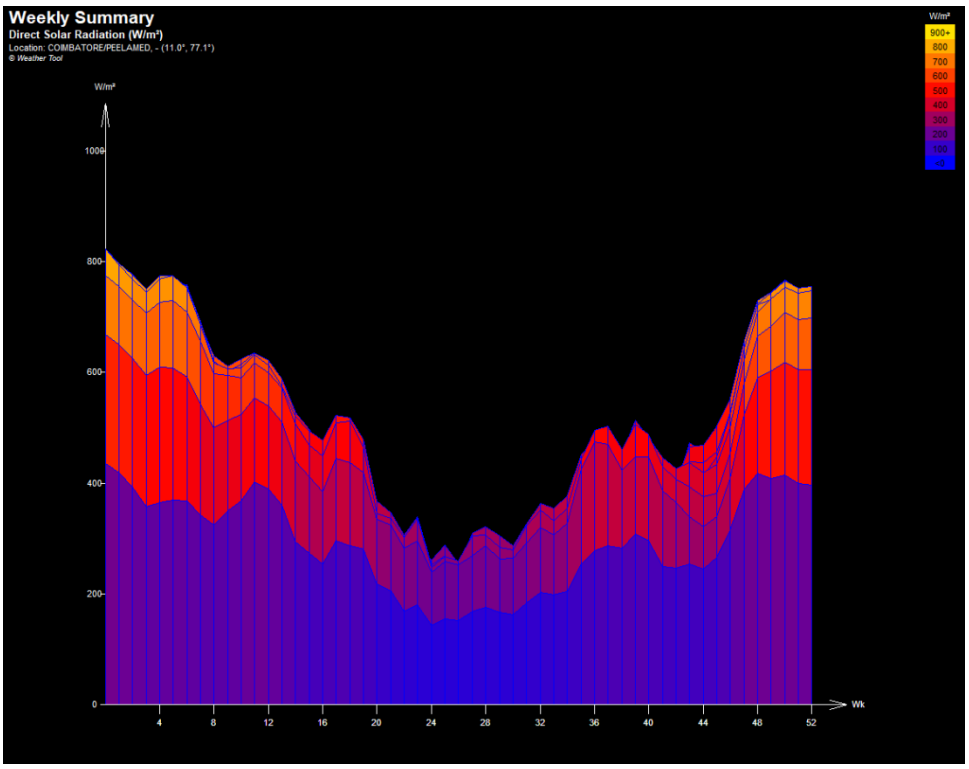


Figure 14, Direct solar radiation (w/sq.)

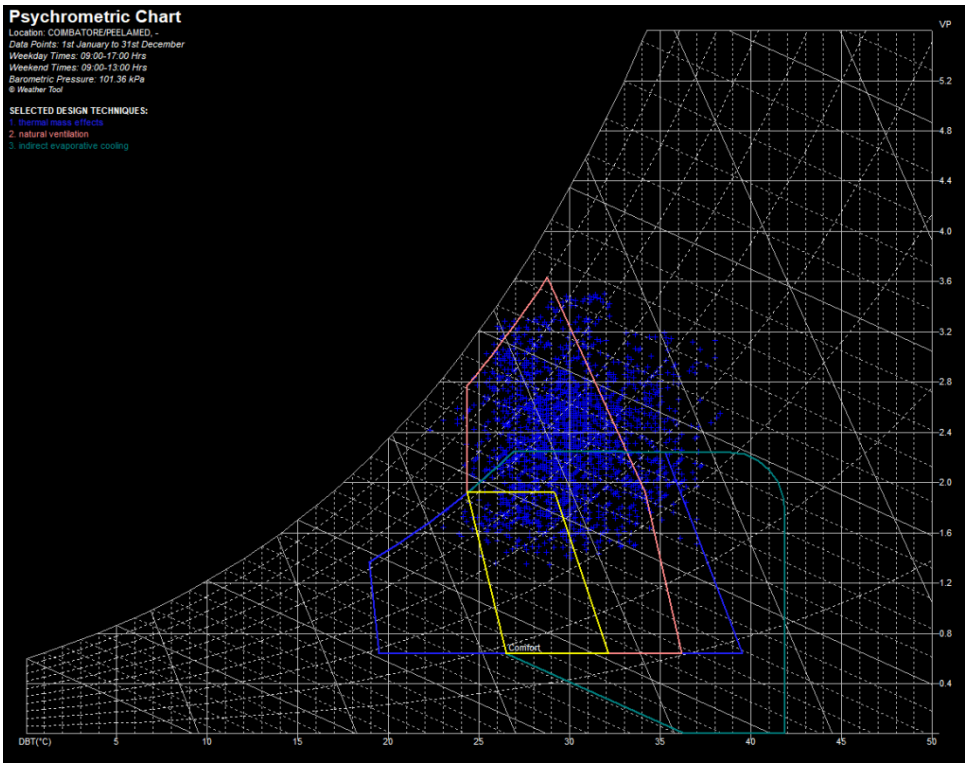


Figure 15, Psychrometric chart describing passive techniques for thermal comfort

DESIGN SUMMARY

As noted previously, the beginnings of this project are rooted to contribute to tackle climate change through design. It's essential to work on towards zero concept to have a great deal of change in coming years, which starts from the design stage itself. This will be briefed out in detail as follows.

OVERALL DESIGN APPROACH

As noted in Design Brief, the design process began with the definition of functional and performance programs of the project. With functional and performance programs defined, energy benchmarking was performed on various forms, finally one conceptual form was identified among them as energy efficient. Performance benchmark were been carried using form it for quicker identification of performance. Later on, orientation and massing for the same is been done for optimization with limiting floor plate size, thermal mass and WWR. External shading devices are design in detail (refer data analysis) to optimize the thermal performance and daylighting with zero glare. Since service core play an important role in office spaces this was been given higher preference while designing the internal spaces.

PROGRAM

Following the site description and climatic data, the next phase of the design process was determining the essential functional elements that are needed for an office campus. The program is comprised of elements for employees, as well as public/ visitors. Landscape also programmed through various study and analysis (refer data analysis).

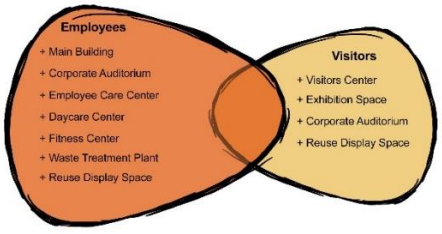


Figure 16, Major functional elements

The public program consists of a various public gathering space along with the employees to interact with them. over a particular zone which includes, corporate auditorium and product exhibition space.

Employees program consists of various spaces for them to work, relax, collaborate, keep them healthier and cared. Which includes, main building along with meeting rooms, cabin, casual meeting spaces, indoor play, food court, productive landscape, fitness center, employee care center, day care centers and outdoor play.

SCHEMATIC DESIGN

Initially all the buildings were been placed along the higher elevation point of the site and with response to the major site access road for easy access into the space. It's been planned to restrict the vehicle circulation inside the campus and encourages walking/ cycling inside the campus for circulation. This reduces the carbon footprint by vehicles inside the campus. Rainwater catchment area is placed at lower level of the site. Waste management and Solar plant are placed at NE part of the site facing the southern direction at 18° tilt for efficient production. Major buildings were been oriented in such a way that longer facades facing north-south direction which minimizes heat gain into the space. Various forms were been simulated for energy benchmarking, among them octagon and circle are energy efficient. The breakdown of energy result indicates superior function of octagon space for saving electric lighting by 0.5% than circle, so that octagon form is been finalized for main building form. This is further massed with few limits such as floor plate sizing of 18m width (for efficient day lighting), single office building with integrated landscaping features and semi high rise which accommodates 15,000 employees. By considering all these factors form is optimized with central green space surrounded by main building with floor plate sizing of 18m, this leads to high rise structure, so that two building floor plate with central spacing between them of 6m is provided so that semi high rise building is obtained, but there is wastage of space in between. At this point

introduction of solar chimney from the inspiration of termite mound is been introduced into design such that stack effect plays a vital role in achieving the thermal comfort, now the solar chimney is given additional purpose of achieving daylighting into the space. Now the central space left for daylighting is been replaced with solar chimney of 6 x 6m so that additional workspace can be provided. This solar chimney is provided on every zone with c/c spacing of 18m for equal distribution of daylighting.

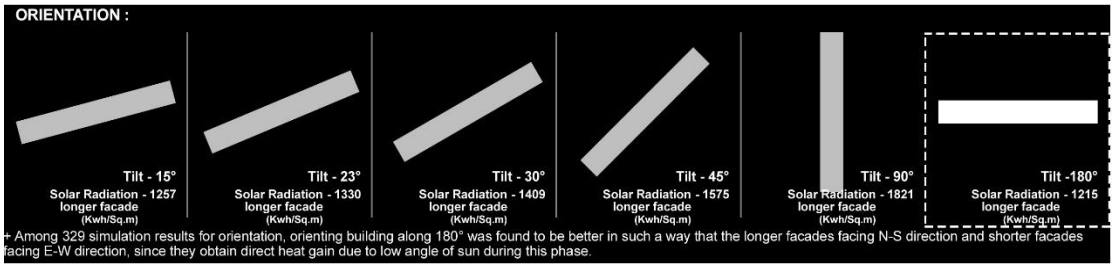


Figure 17, Describing optimal orientation

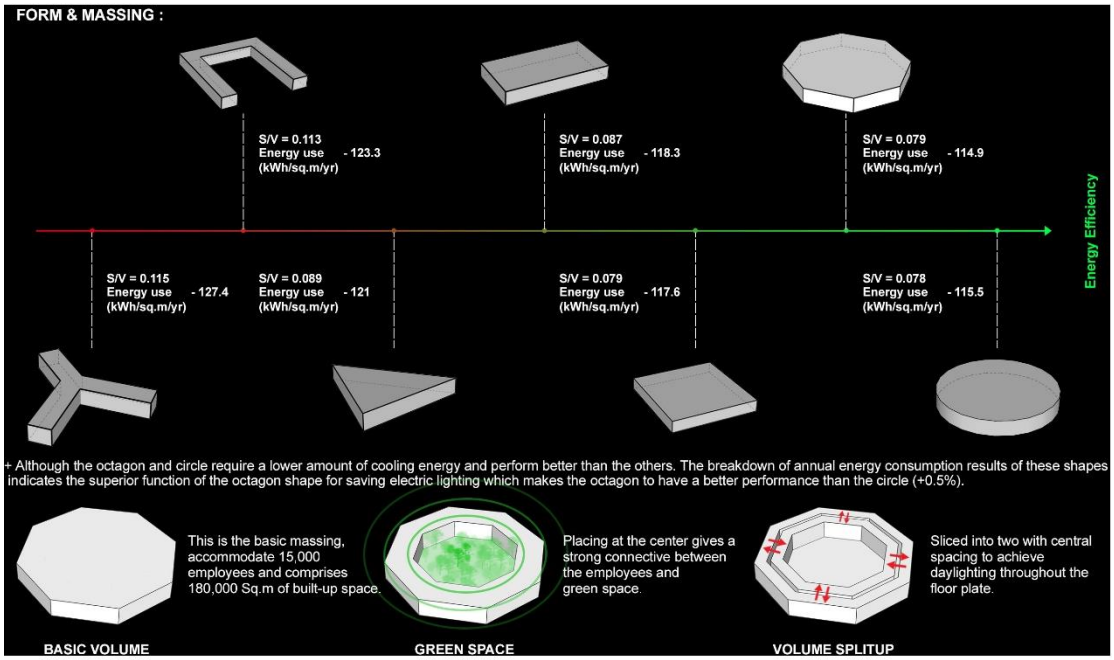


Figure 18, Describing optimal form and massing

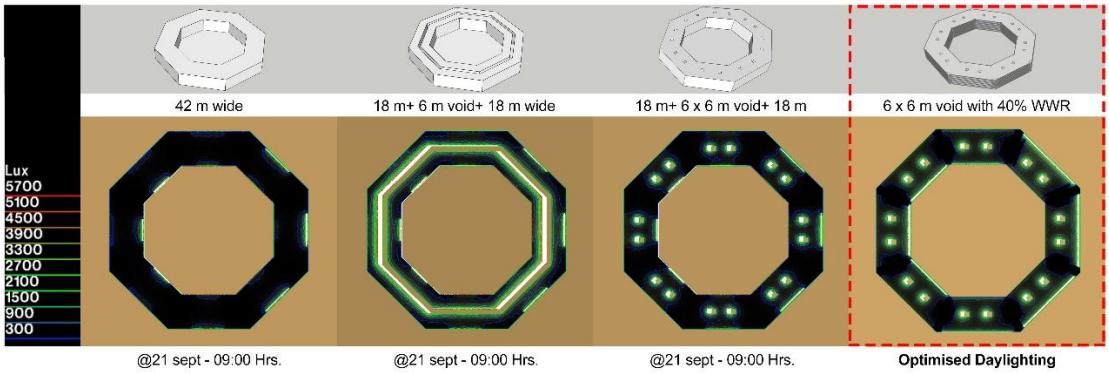


Figure 19, Describing form optimization in relation to daylighting

DESIGN DEVELOPMENT

Master plan

The final master plan is a combination of various factors such as internal circulation is based on minimized detour path system, such that the overall length of the path is minimized. By this system maximum distance of travel of a path is 500m, which is mostly accepted walking distance. Since most of the points are interlinked to main building, we have made an outer circumference which acts as circulation path. Here all the internal circulation path is of 3.6m which is said to be the proxemics distance human being consider for social distance, which encourages interaction between unknown persons.

As per crime prevention through design guidelines all the external spaces are created in such a way that they are visually clear for a visual surveillance and all the spaces are active enough. The entire campus is pedestrian oriented environment which means that no vehicular circulation inside the campus, this is to reduce the carbon footprint inside the campus and to encourage walking and cycling to keep ourselves healthier. Bicycle pickup /drop points are placed on various locations over the site for ease of access. There is 40% reduction in employees parking space from the base line recommended by TNDCR, this is to encourage the use of public means of transportation. Even the office itself runs a transportation system for the employees which runs on electricity so that overall carbon footprint due to transportation also reduces.

All the circulation path is aligned with trees on either side of the path which are native/ drought tolerant species, they are placed in such a manner that it induces the employee's mood by their color to increase the productivity of employees.

Achieving security and privacy from the public is achieved through internal circulation path and various nodal points. Most of the buildings are oriented in such a way that longer façade facing North-South direction this minimizes the heat penetration into the building space. All the buildings are located in a unified landscape, which extends and connects the interior workspace to outdoor facilities for relaxation, recreation and reflection. Landscaping species were been carefully selected based on native/ drought tolerant species and species for food production for employees, the centralized landscape in main building consist of fruit bearing trees, detailed list of species along with water consumption data is provided at Data Analysis. As a result, only 25% of the site area are impervious. Vegetation are irrigated before the sun rise in order to reduce/ minimize the evaporative loss.

Solar plant of area 36,000 Sq.m which generates 9864 MWh/yr. is placed over the NE corner of the site, the wet and dry cleaning is done once in 15 days, the cleaning water also goes back to vegetation so that there won't be any water waste. Rainwater collected are connected to Sewell which is been connected to lake, this acts as rainwater catchment point and along the way of Sewell reedbeds are planted this reduces the contamination getting collected in catchment point. Through this within two to three years we can see a gradual change in ground water level across the surrounding of this region. Common waste management plant is provided on the NE part of the site, through this zero waste is been sent to landfills is ensured and an interesting feature over this space is that it encourages employee and public access to reuse display area where people can pick up from waste materials for reusing them, this reduces the energy for recycling or any other treatment of the waste materials.

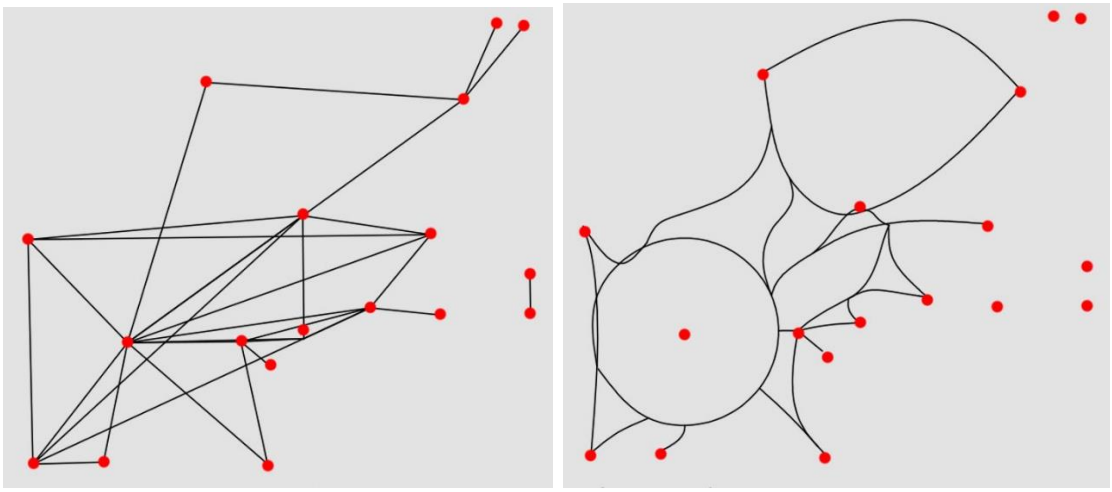


Figure 20, Evolution of circulation path by detour path system

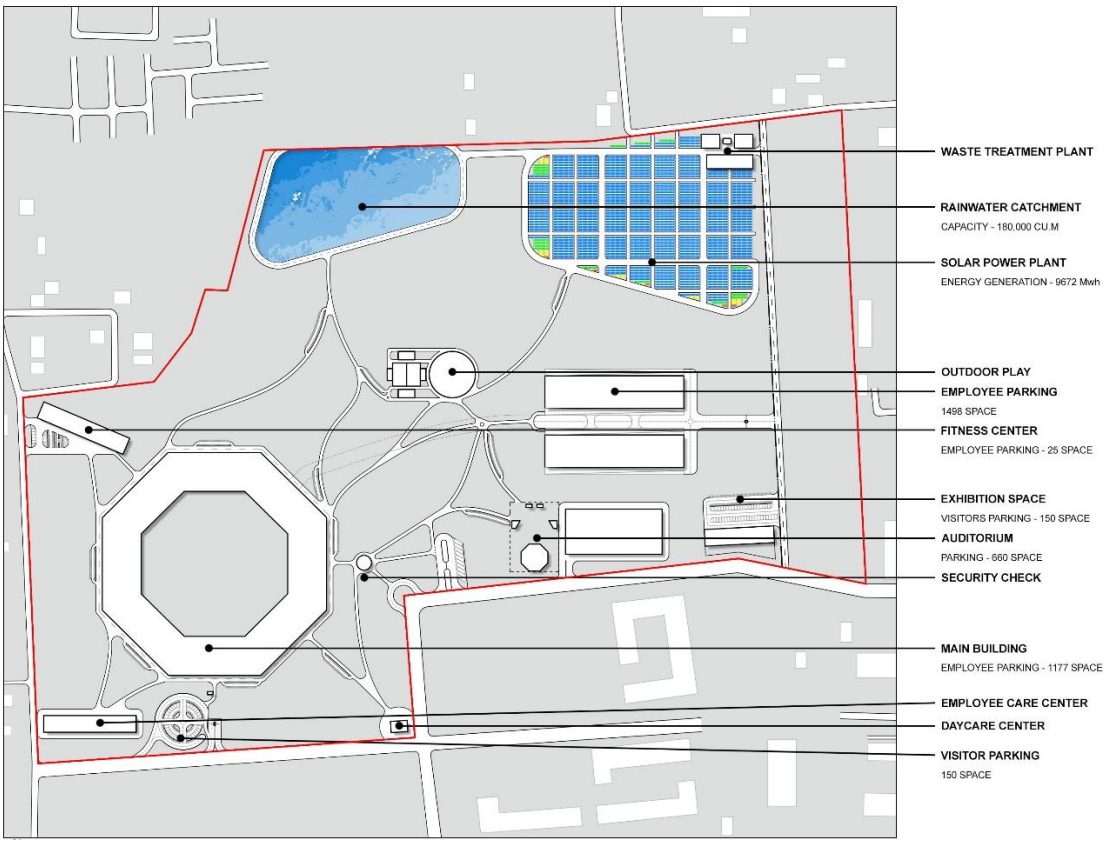


Figure 21, Master plan

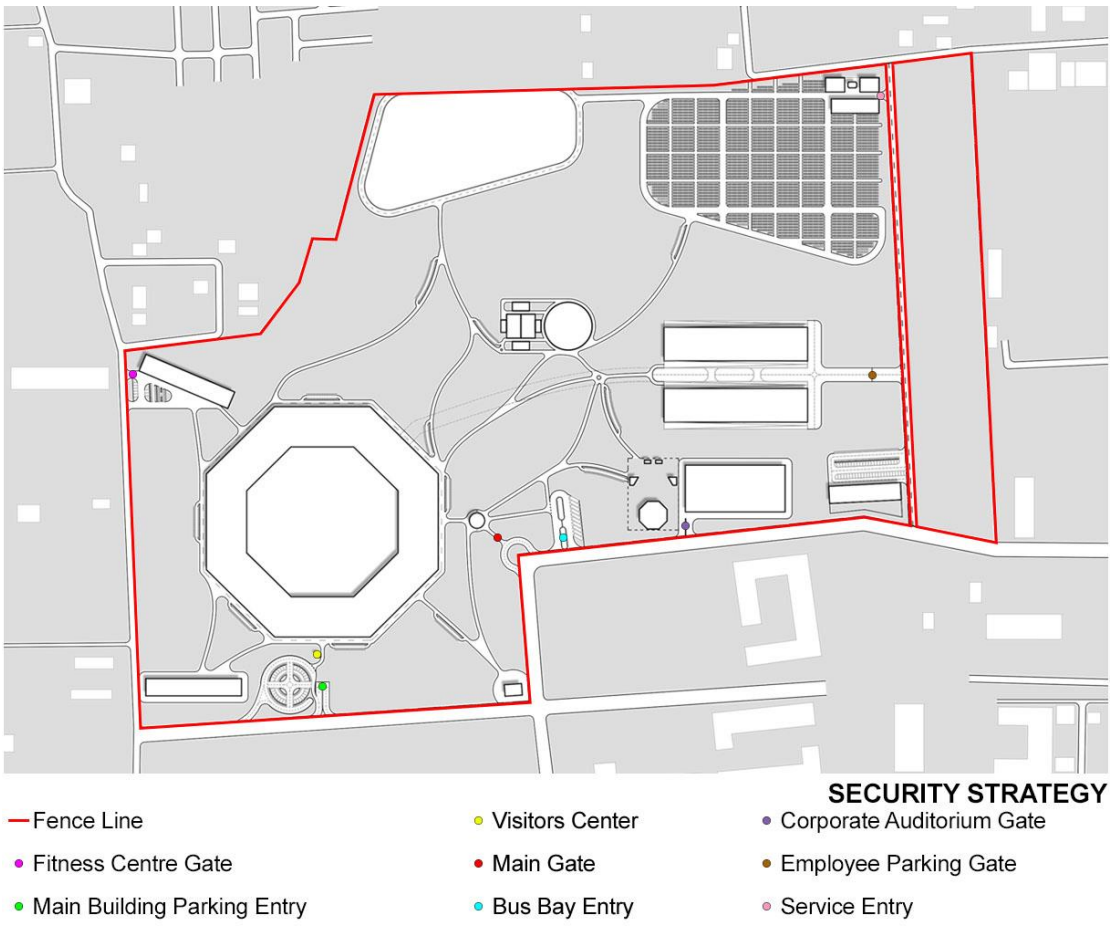


Figure 22, Describing the security strategies incorporated

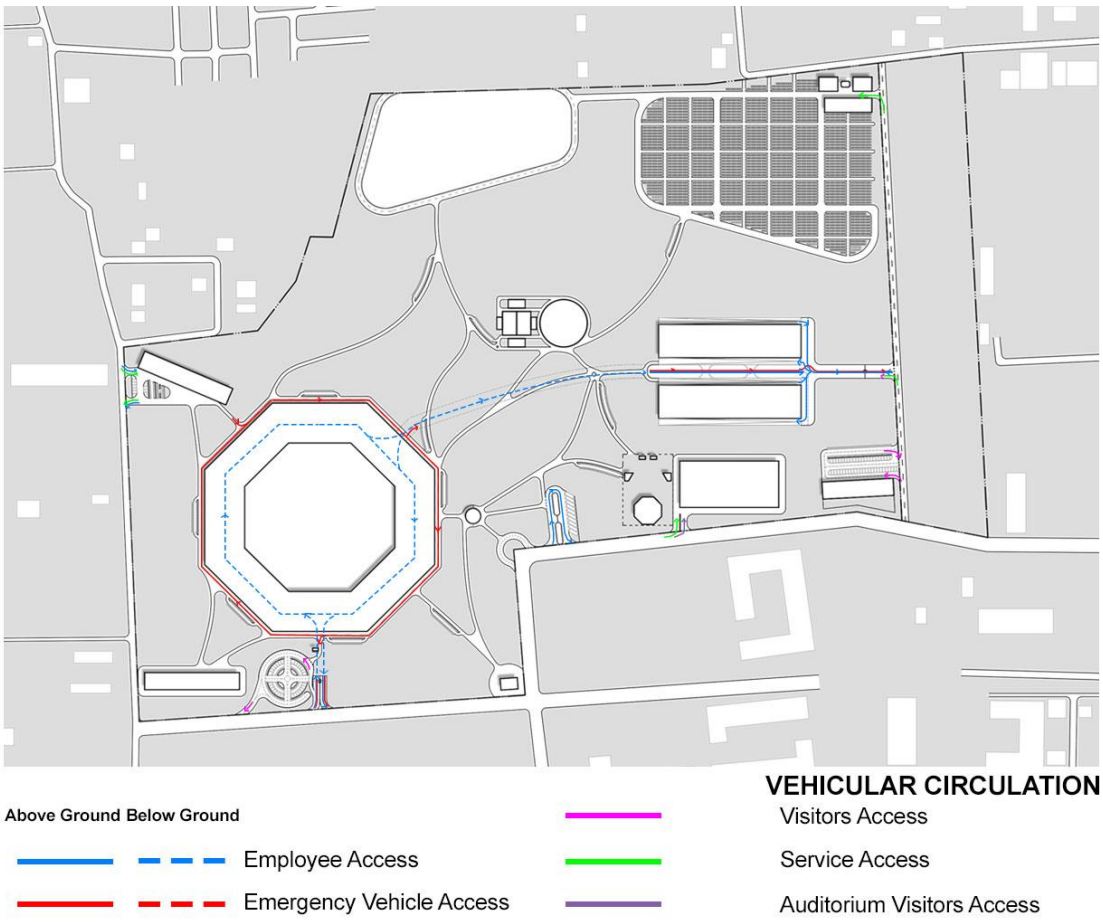


Figure 23, Vehicular circulation

Main Building

The focal point of the campus is the six storied office, main building comprising 180,000 Sq.m built up area above ground. This area also includes the in-building employee services, meeting spaces, office entrance areas and circulation zones. After finalizing the form of the building, the next step is to design a service core, since service core play a major role in office buildings. Here we thought of making eight service cores with similar functions, on all the eight connecting nodal points. since being a large building and accommodates 15,000 employees its essential to have eight service core and further the building is subdivided into eight zones for the purpose of monitoring and services. All the eight cores have the same elements such as reception (gathering space, refugee

area), four staircases, seven lift with one service lift, restroom, café, HVAC room, Hub room.

In eight zones one zone is entirely dedicated to dinning space which accommodates 1602 dinning space (804 at ground level and 408*2 at mezzanine level). North-Eastern zone is dedicated for dinning which give wide range of view inside the campus along with play area. Dedicated preparation area is been left out for veg and non-veg preparation housing cold and freezer room for the same. Here it’s been entirely self-servicing space since as per a study food waste is minimized through self-service, five individual serve space is been provided on either side of the zone with plate drop vehicle placed in front of the handwash space.

Other seven zones are dedicated to workspace which accommodates 402 employees per zone with two cabins, two eight-seater meeting room and one twelve-seater meeting room along with casual meeting spaces and central casual seating space along with table for board games to keep employees relaxed. Throughout the building placing and spacing were been done based on circulation pattern with ease of access. Building management system is been provided at the ground floor east zone which monitors the entire building, so that it ensure no sick building syndrome is found inside the building by monitoring the air flow and its contaminants, energy monitoring... Air quality monitors are placed at regular interval inside the zone to keep tracking and ensuring good air quality inside the space.

This office is not been air conditioned through conventional means rather the air ducts were been provided to circulate natural ventilation throughout the space with elevated air speed and triple filtering, this ensures thermal comfort for 85% of the days in a year and the balance 15% of the days thermal comfort is achieved by a means of radiant cooling system. By this energy demand for air conditioning the workspace is reduced at a great extent. As said earlier to achieve adequate daylighting inside the workspace each zone consists of two solar chimney which not only acts to achieve thermal comfort through stack effect, but also to ensure daylighting inside the workspace. This is been placed at a distance of 18m c/c

for equal distribution of daylighting inside the space. Additionally, window wall ratio (WWR) is ensure 40% as recommended by ECBC and daylighting shelves were introduced which ensure the daylight penetration deep inside the space. Further to minimize the glare and heat gain inside the space three kinds of shading device is been provided this will be detailed out in data analysis section. On the top of solar chimney, it's been painted dark this ensure heating up that particular space quickly which induces convention so that hot air from inside the building space is been sucked out much quicker in a passive way with stack effect. All the external glazing are double glazed along with argon gas infill at the center to reduces the heat gain inside the space, efficient wall insulation is been provided such that it increases the thermal lag, so that heat penetration into the space is reduced (this will be detailed out in data analysis section). The building top is been provided with monocrystalline solar panels which satisfies 49.74% of the energy demand.

Basement one and two is dedicated for employees parking space which is accessible through 1:12 slope road from employee parking gate and employees parking lot at east side of the site. This basement parking is also accessible through the central green space, it has a parking capacity of 1177 spaces including dedicated space for electric vehicle and accessible parking, turning radius is been ensured as per the guideline from TNDCR.

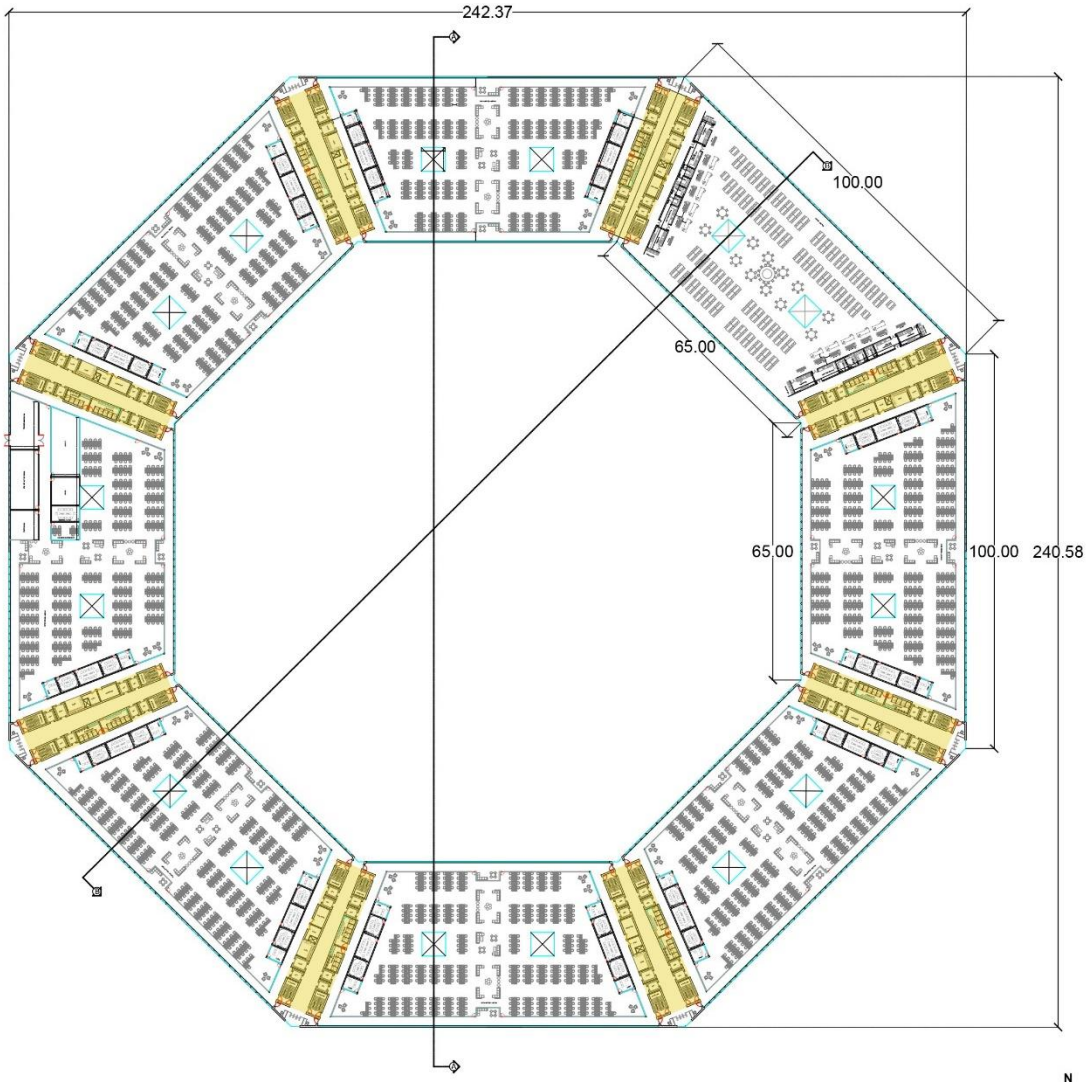


Figure 24, Main building (Plan-G)

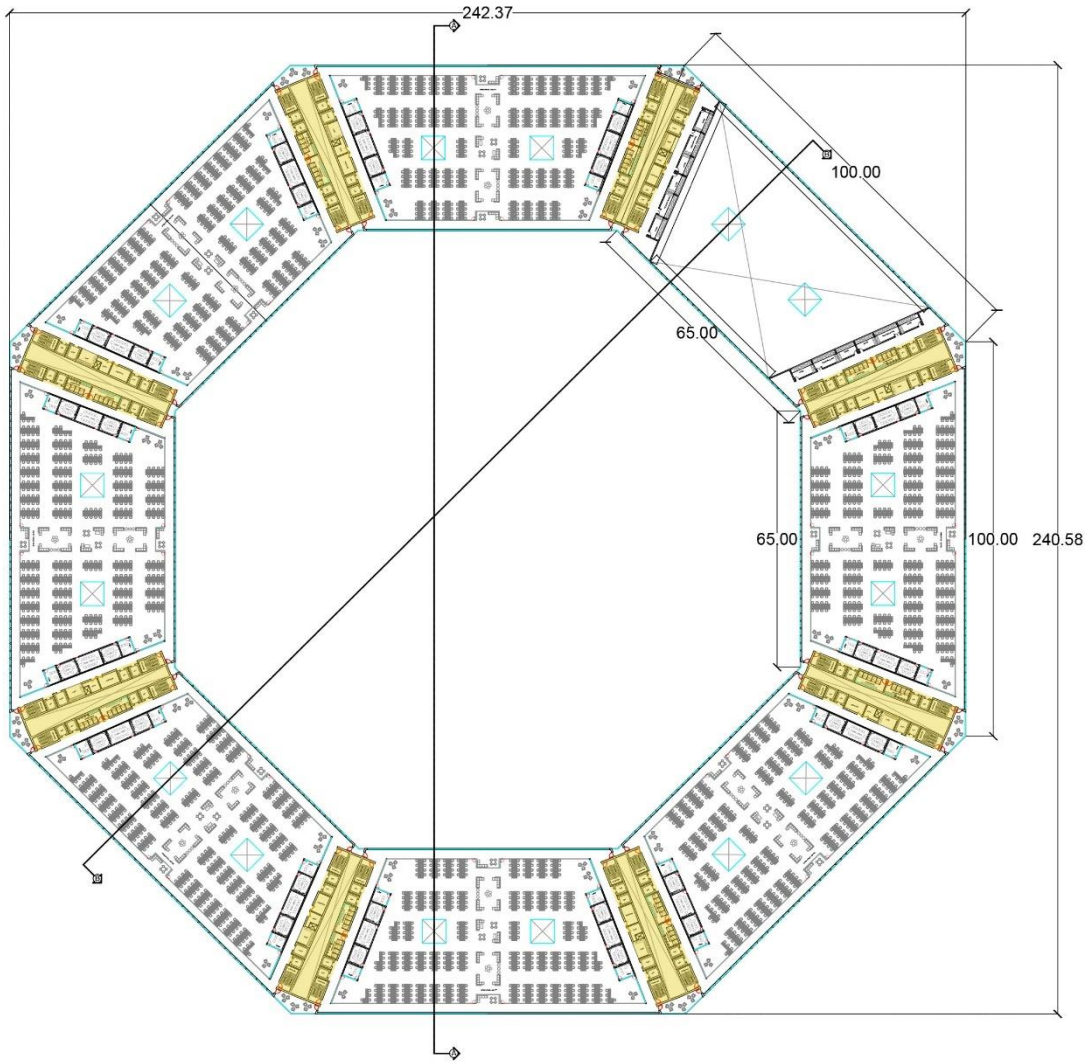


Figure 25, Main building (Plan – Typ.1)

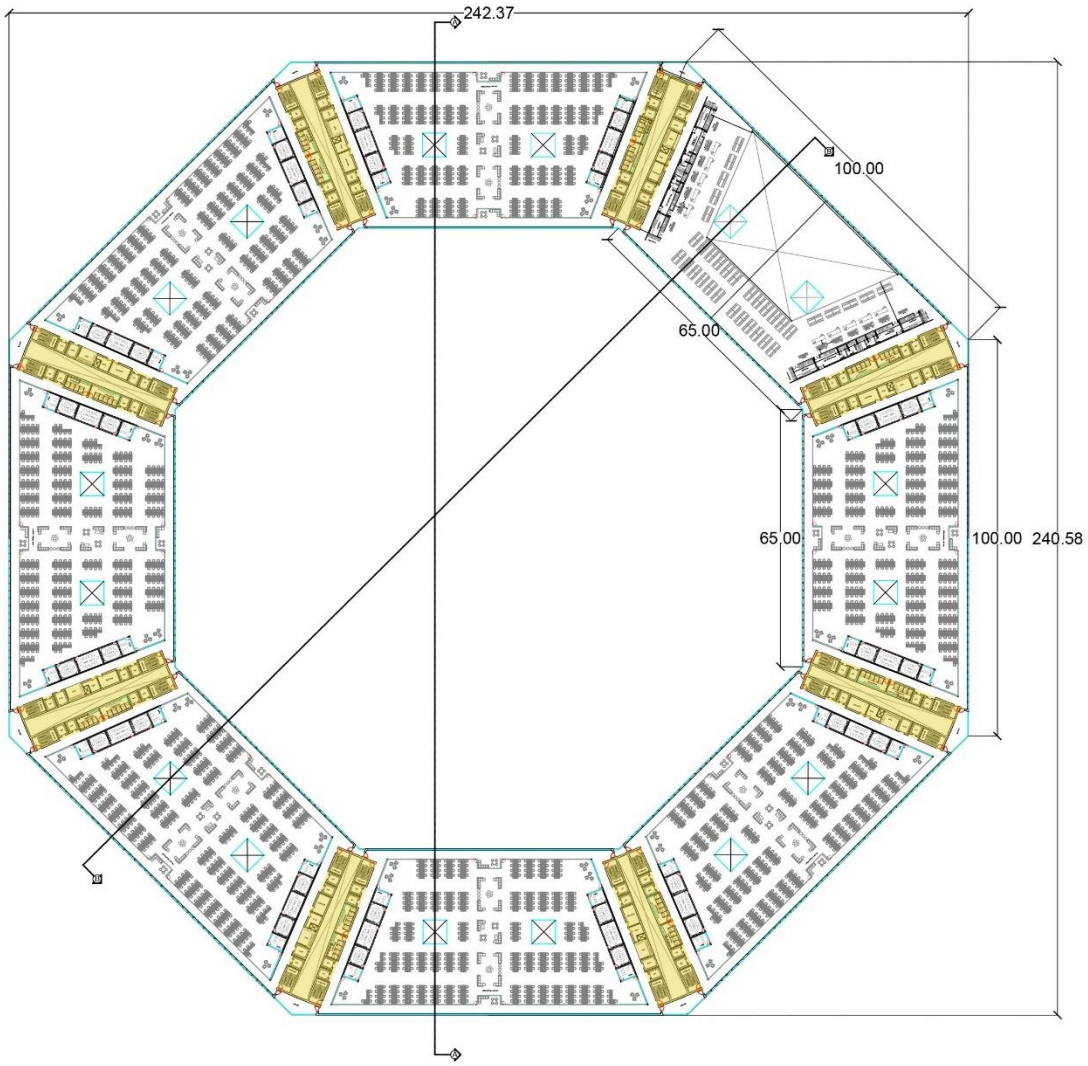


Figure 26, Main building (Plan – Typ.2)

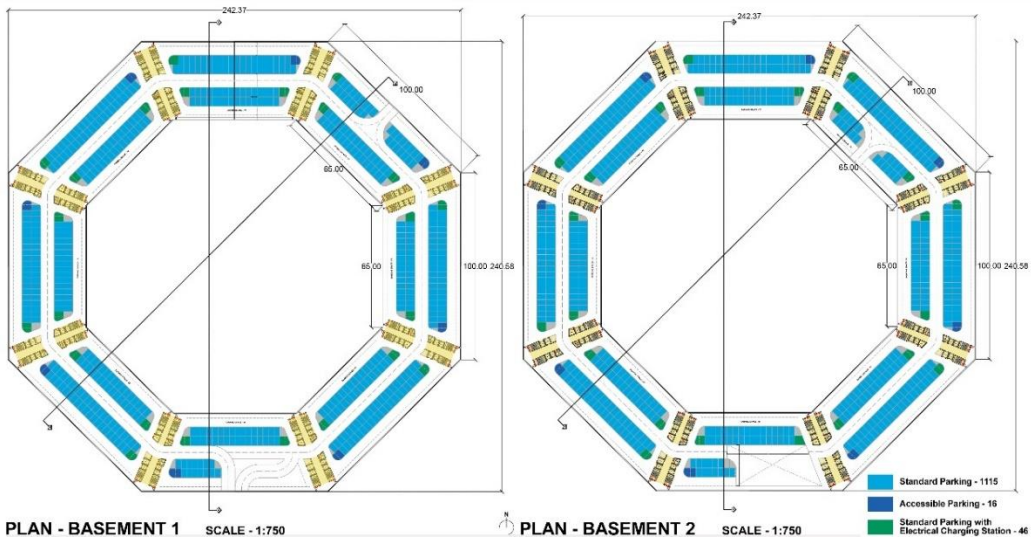


Figure 27, Main building (Plan – B1& B2)

Figure 28, Service core (G& Typ.1)

Figure 29, Service core (Typ.2, B1& B2)

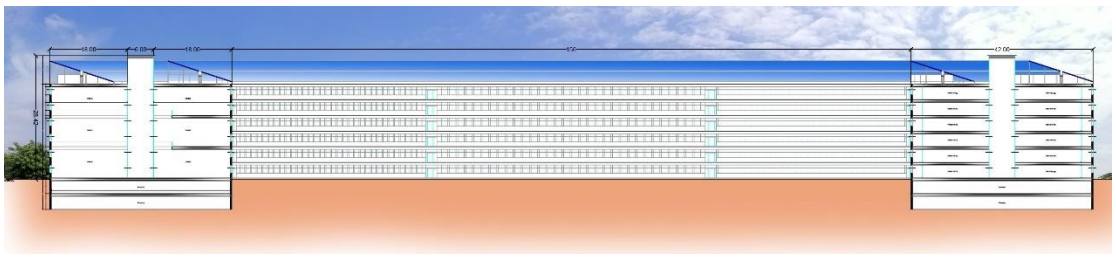


Figure 30, Main building typical section

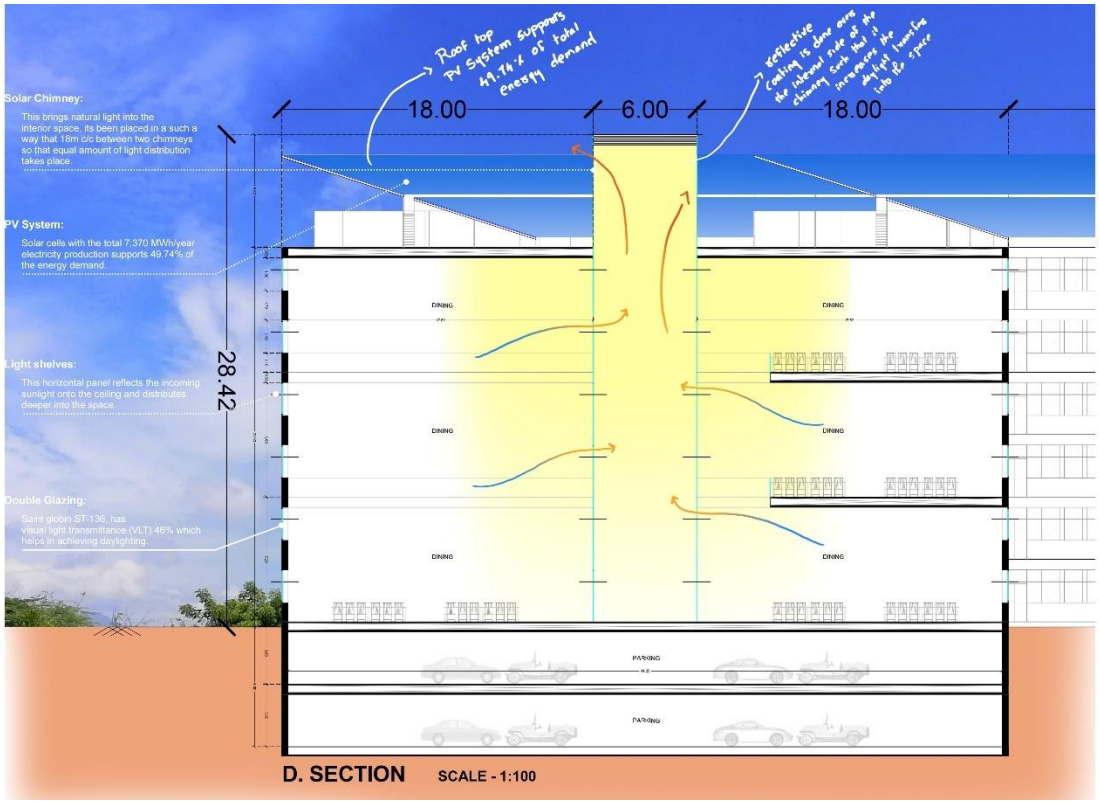


Figure 31, Main building section (dinning space)

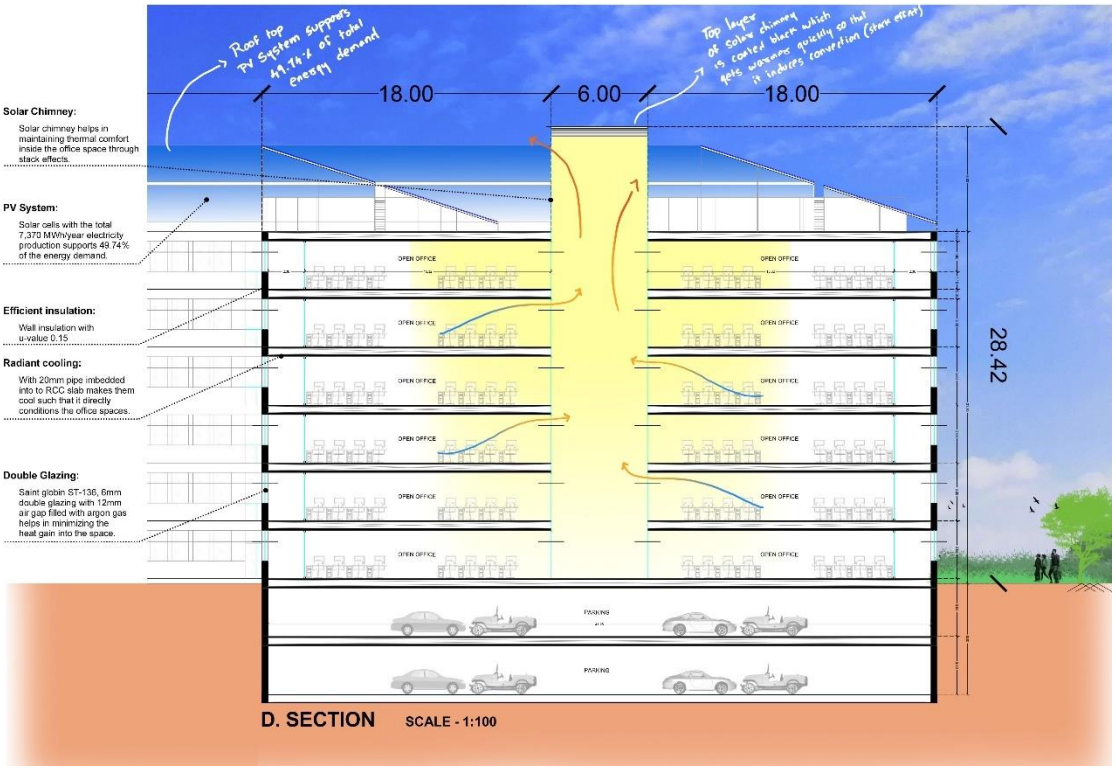


Figure 32, Main building section (open office)

Figure 33, Visualization of main building and security center

Figure 34, Visualization of main building and green space linkage

Corporate Auditorium

An assembly space with fixed seating for 1,000 people is proposed for the south-eastern part of the site comprising about 3,460 Sq.m with is accessible through foyer at ground level, rest of the space is submerged into the ground. The foyer space above ground resembles similar form that of main building. An open plaza for gathering is provided at ground level about 3100 Sq.m, which is adjacent to auditorium foyer space. Auditorium seating are placed based on horizontal and vertical angle of vision, such that everyone gets a clear vision to the stage. The building also will contain a large foyer space, multipurpose space, back stage, washrooms and supporting spaces. The corporate auditorium will be served by 660 parking spaces adjacent to auditorium.

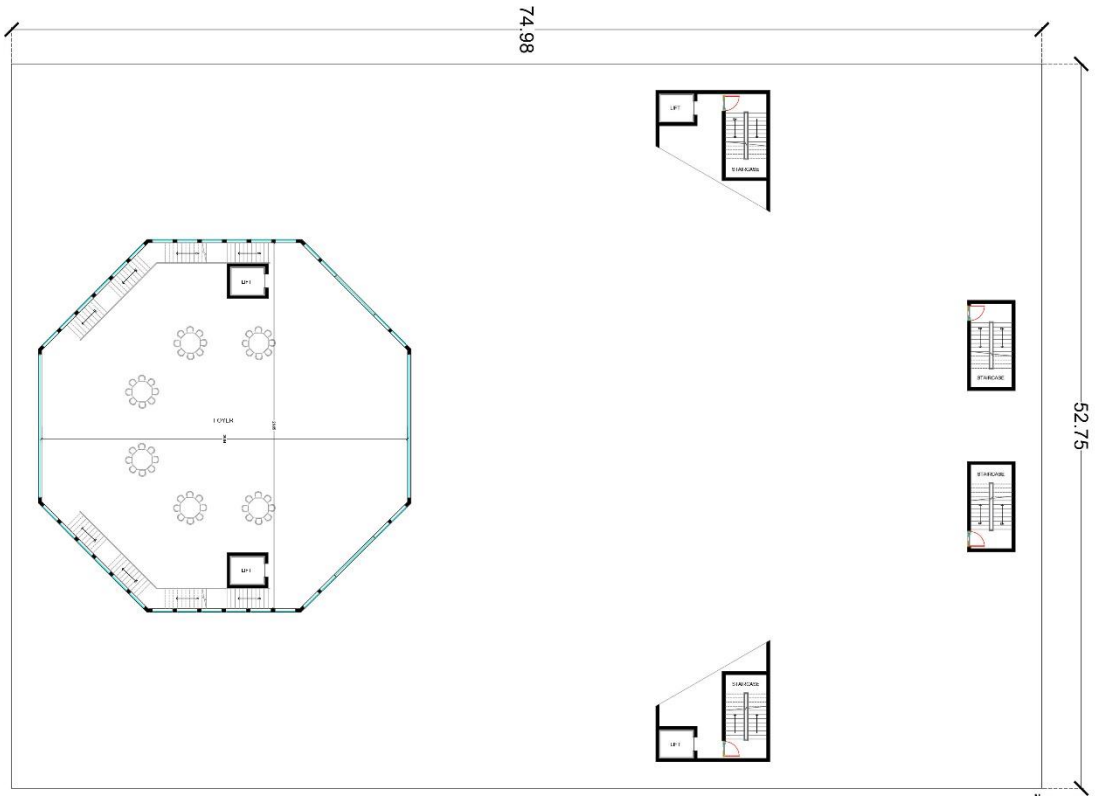


Figure 35, Auditorium (Plan-G)

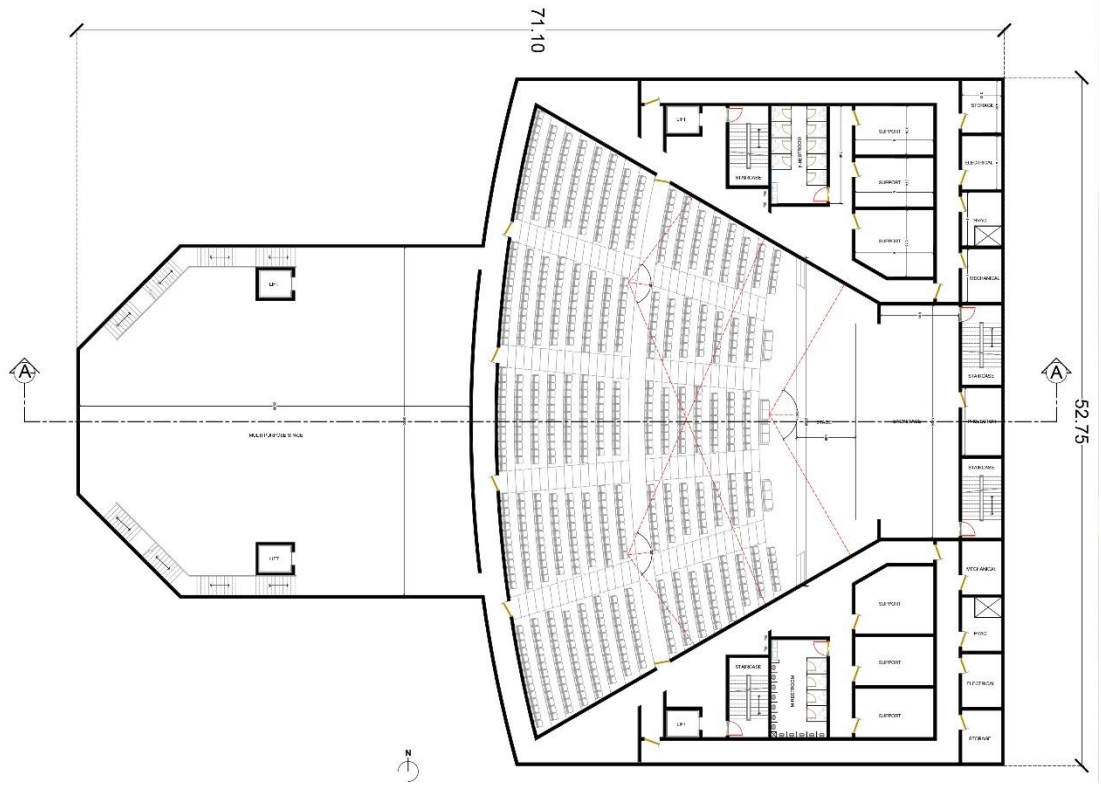


Figure 36, Auditorium (Plan-B1)

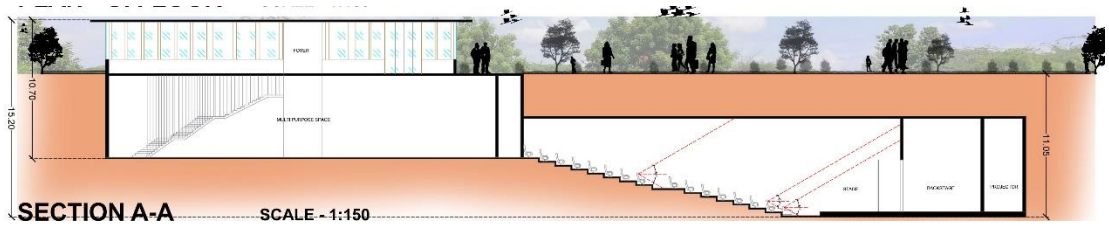


Figure 37, Auditorium (Section)

Figure 38, Auditorium (Visualization)

DATA ANALYSIS

As described earlier, the methodology for this study required the establishment of a minimum (base line) level of functionality and performance for the final design (refer Towards Zero section). The methodology used in the overall design process described in this study ultimately yielded a final performance-based design with substantial performance improvements over the base line design. The main case was to achieve better performance of Towards Zero concept than that of base line recommended by USGBC in achieving LEED Zero. In simple words, the final design is predicted to demonstrate better functional performance by following Towards Zero.

DAYLIGHT ANALYSIS

Daylighting describes the act of lighting the interior of a building with daylight. The objective of daylighting is to enhance visual comfort conditions for building occupants and to reduce the overall energy use of the building. This section briefs about the day lighting analysis carried out to determine the compliance with LEED v4.1, Indoor Environmental Quality (EQ) credit : Daylight. The requirement of the credit is to achieve daylight illuminance level of minimum 300 lux and maximum of 3000 lux in a clear sky condition on 21 September at 09:00 hrs. and 15:00 hrs., at working plane on regularly occupied area. Daylighting is facilitated through careful choice of building massing, façade orientation, daylight shelves and layout. later on, suitable electric lighting and shading control strategy has to be identified to reduce electric lighting use and mange incoming solar gain. Daylighting can be measured in illuminance, UDI (useful daylight illuminance) and DF (daylight factor). Illuminance : a visual rendering of a scene, which is what you would see with your naked eyes, is a way of mapping the luminance of the object in the scene.

Methodology adopted:

Daylight analysis has been performed on radiance and building has been modeled in ecotect based on the architectural drawings. Daylight illuminance analysis has been performed on 21st

September at 09:00 hrs. and 15:00 hrs. outside lux has been taken from EPW weather file of Coimbatore.

Simulation assumptions:

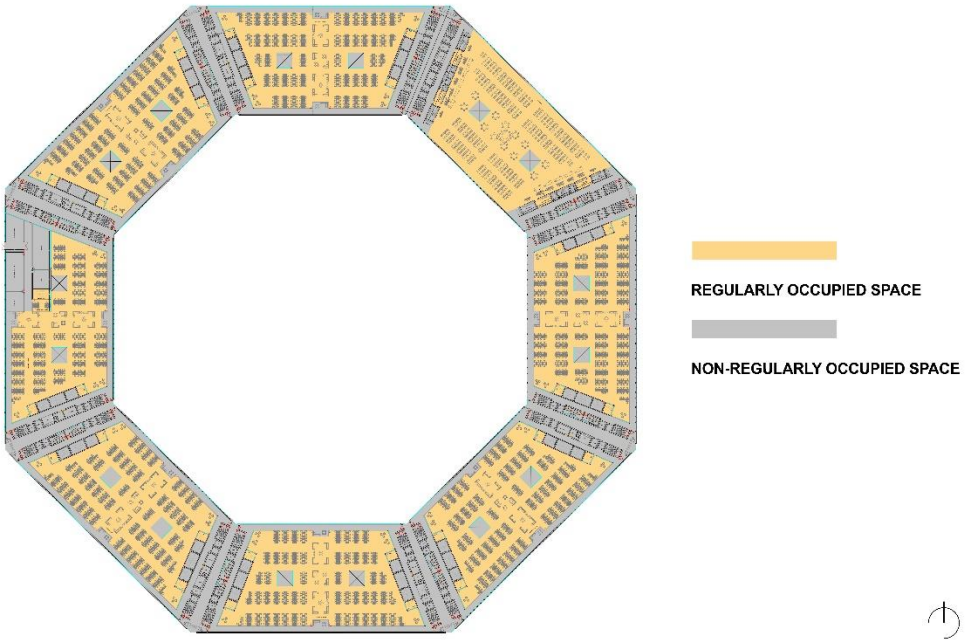
Properties of material had been assumed to perform daylight analysis. These are as follows:

Sr.No.	Category	Specification
1	Walls & Columns	60%
2	Ceiling	80%
3	Floor	40%
4	Glass VLT	50%
5	Date & Time	21st September 0900 and 1500 hrs. (as per LEED v4.1 EQc : Daylight)
6	Weather File	Coimbatore/ peelamed, meteonorm wea
7	Grid surface plane	@ 750 mm from the floor plate at working plane height
8	External shading devices	As per the architectural design

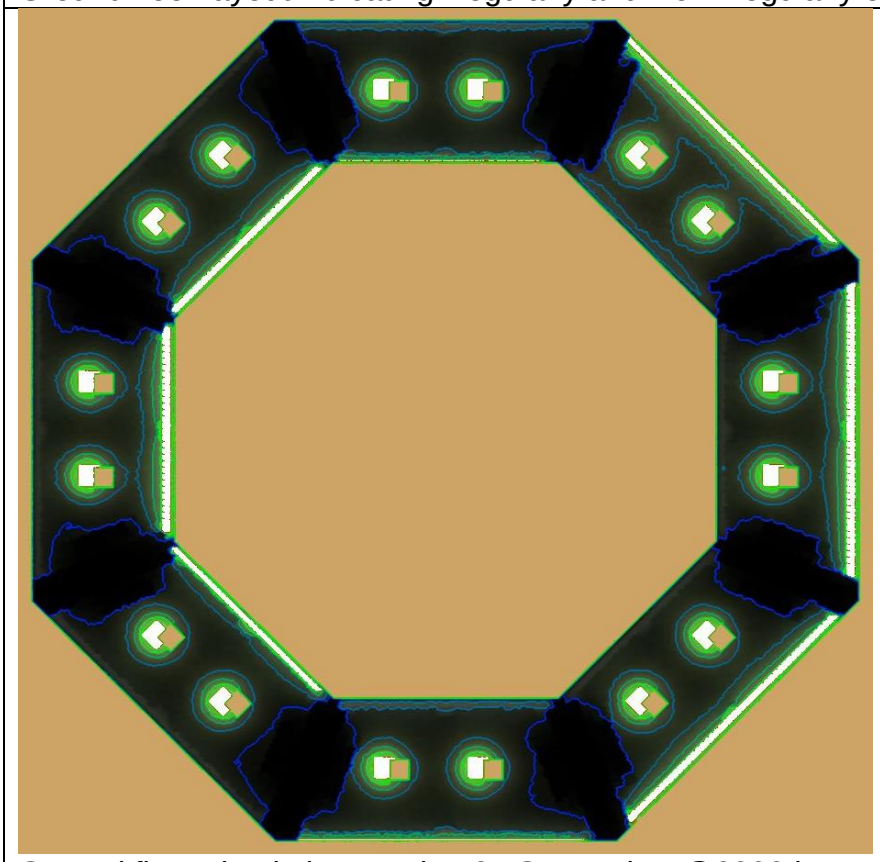
Table 4, Daylight simulation assumptions

Identification of regularly and non-regularly occupied spaces:

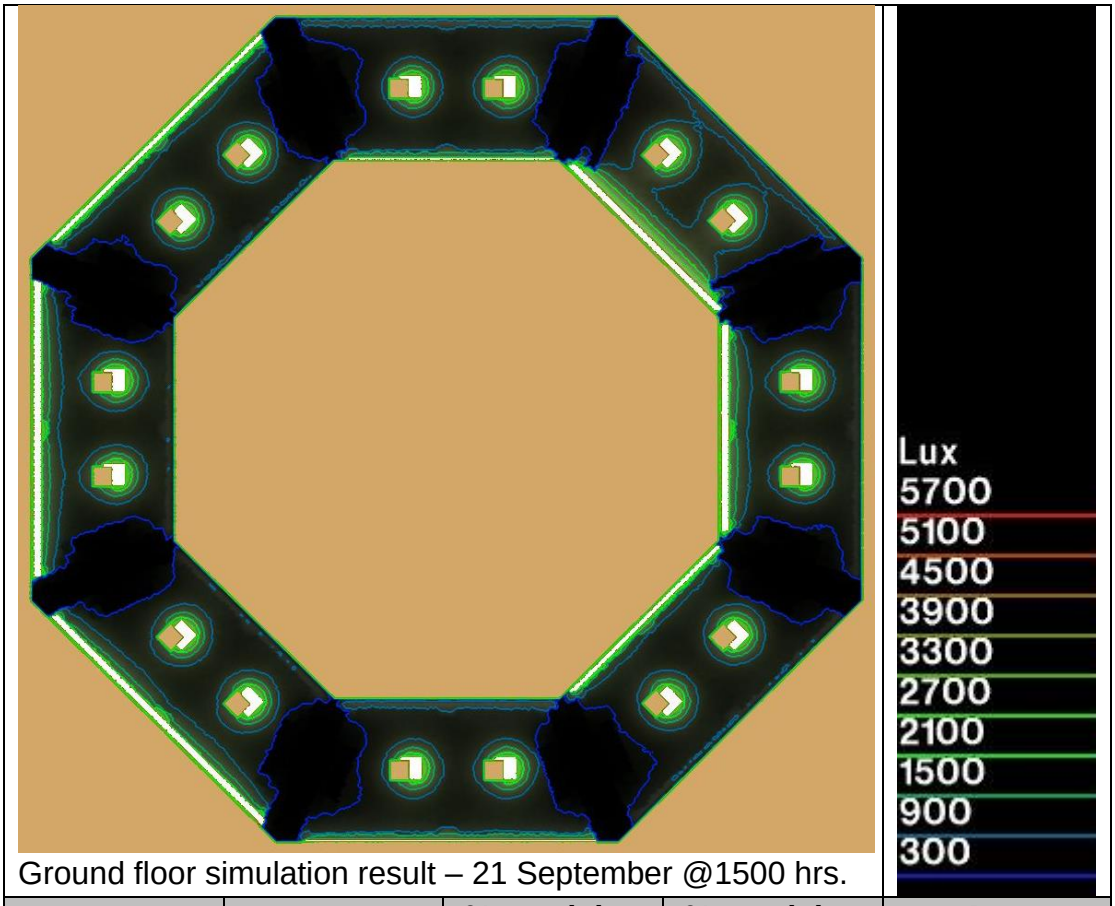
Regularly occupied areas are those where people sit or stand as they work, irrespective of the number of days occupied in a year. Regularly occupied areas in a typical office unit include; workstation, cabin, kitchen. Spaces such as service areas, toilets, lifts, pantry, dining and lobbies are considered as regularly occupied areas since occupants do not spend more than 1 hour in average per day.



Ground floor layout indicating Regularly and Non-Regularly occupied space



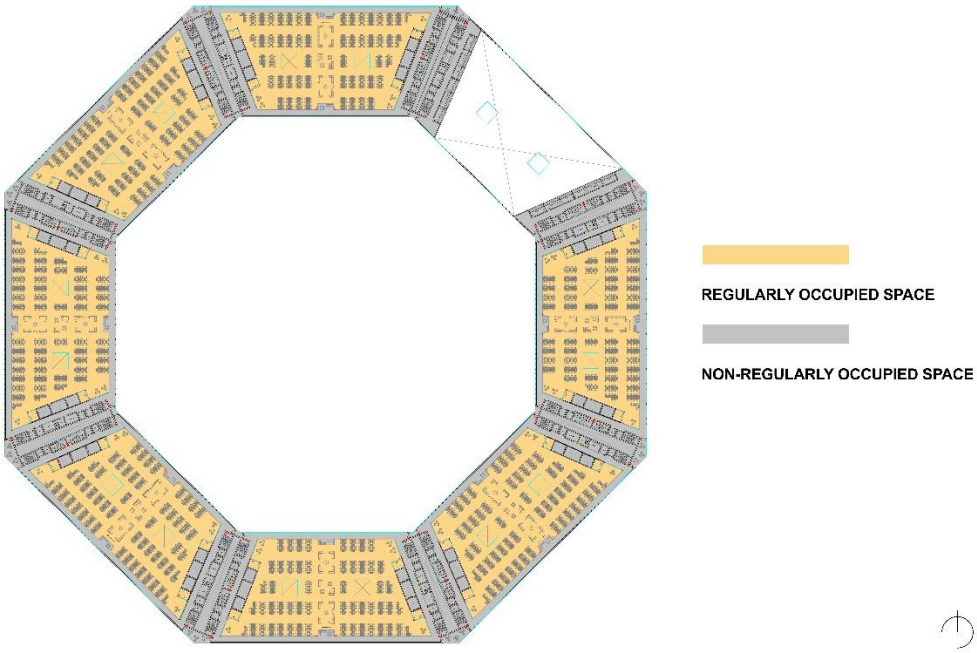
Ground floor simulation result – 21 September @0900 hrs.



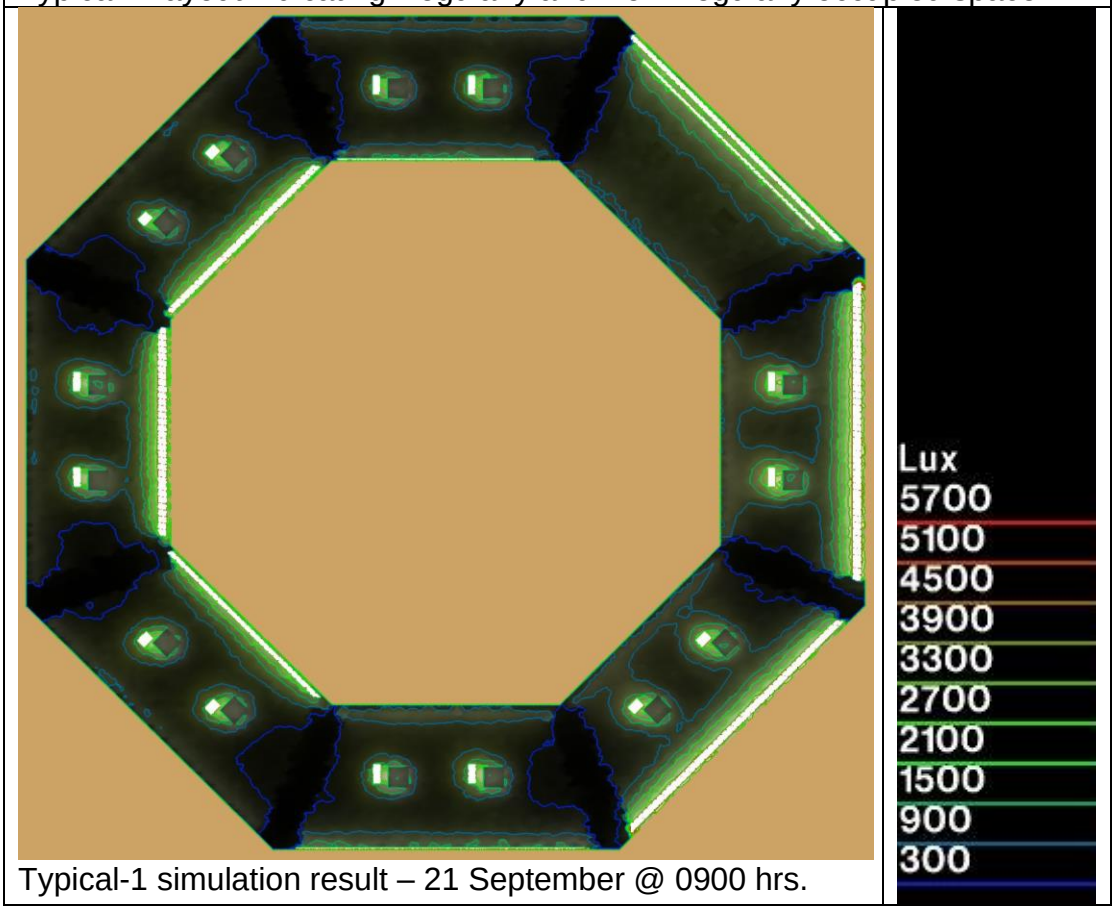
Ground floor simulation result – 21 September @1500 hrs.

Floor	Reg. Occupied Area (Sq.m)	% receiving (300 - 3000 lux) @ 0900 hrs.	% receiving (300 – 3000 lux) @ 1500 hrs.	Avg. minimum Daylight Area (Sq.m)
Ground	19280	97.59	97.45	18802

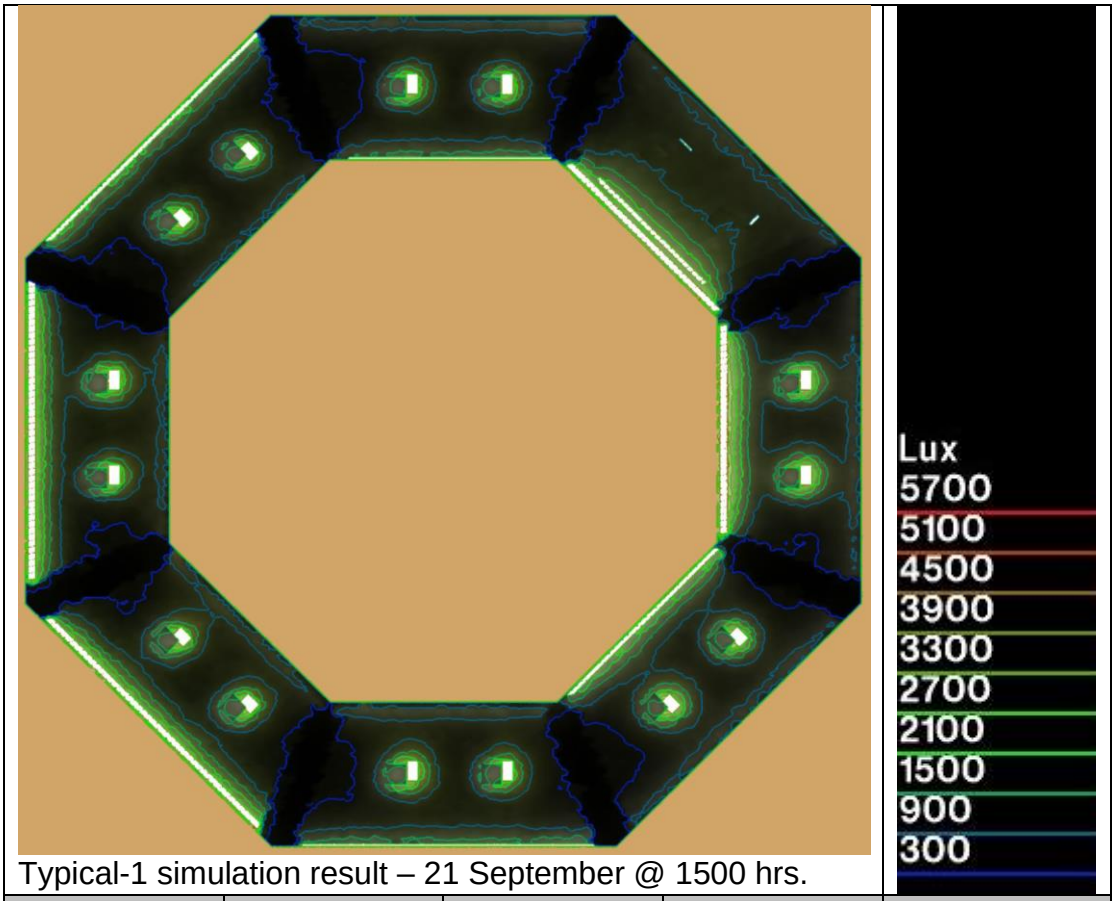
Table 5, Ground floor daylight analysis



Typical-1 layout indicating Regularly and Non-Regularly occupied space



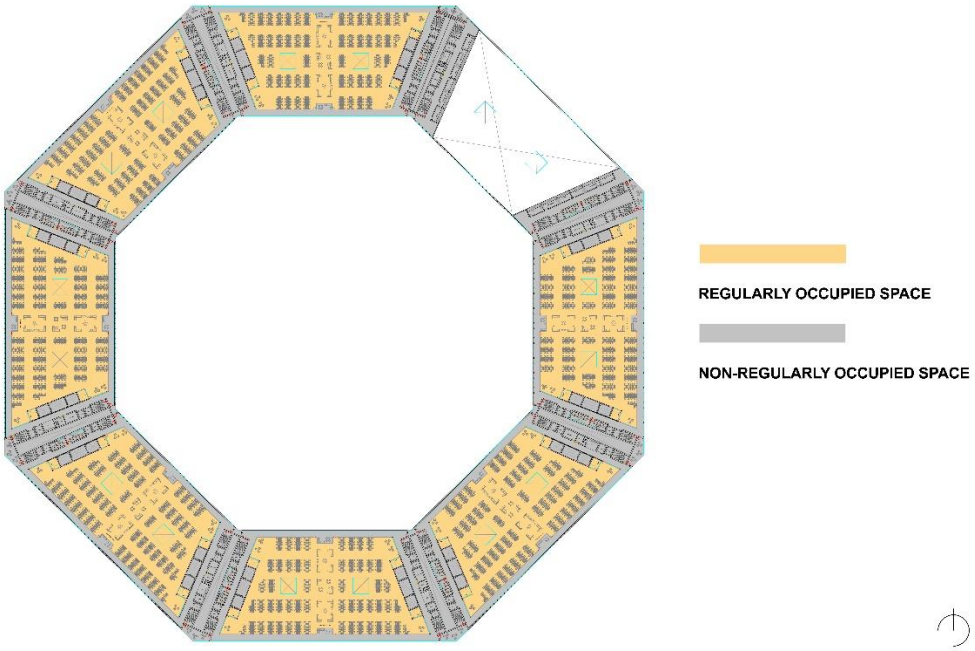
Typical-1 simulation result – 21 September @ 0900 hrs.



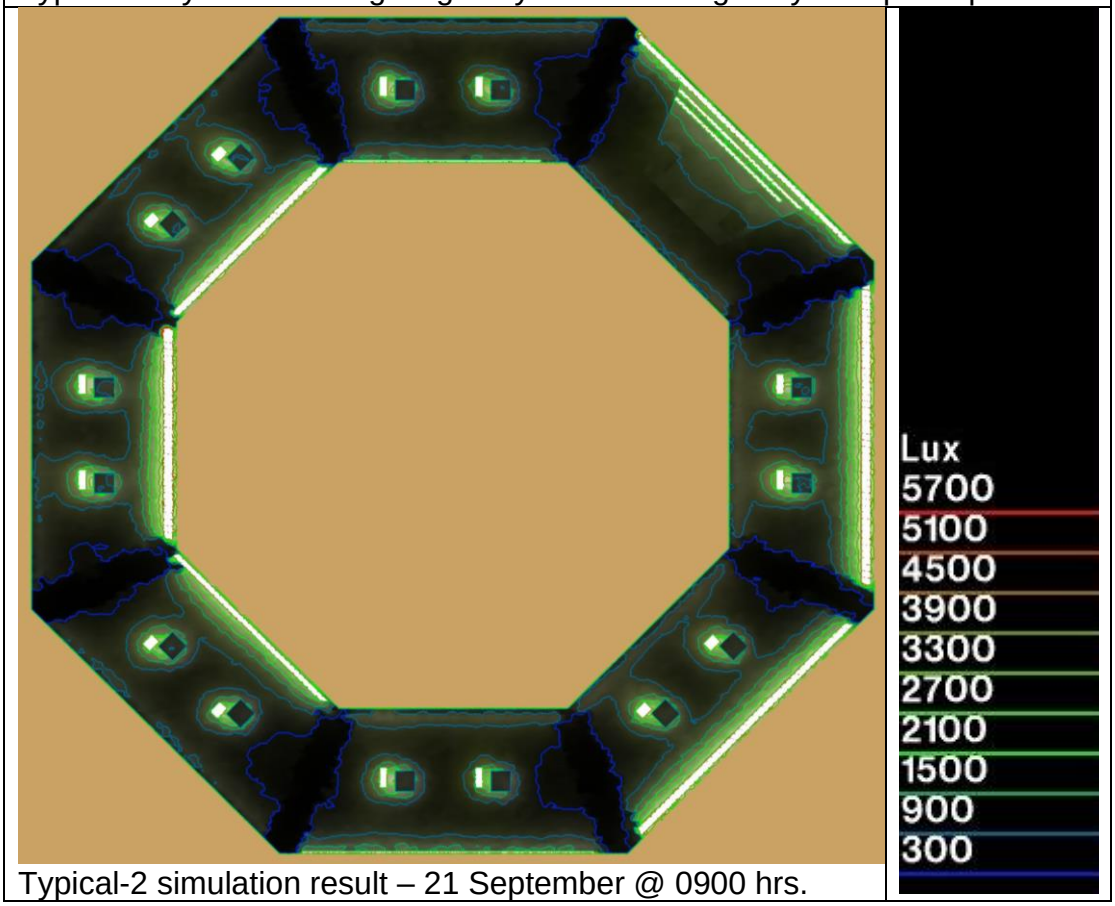
Typical-1 simulation result – 21 September @ 1500 hrs.

Floor	Reg. Occupied Area (Sq.m)	% receiving (300 - 3000 lux) @ 0900 hrs.	% receiving (300 – 3000 lux) @ 1500 hrs.	Avg. minimum Daylight Area (Sq.m)
Typical-1	50610	97.72	98.83	49737

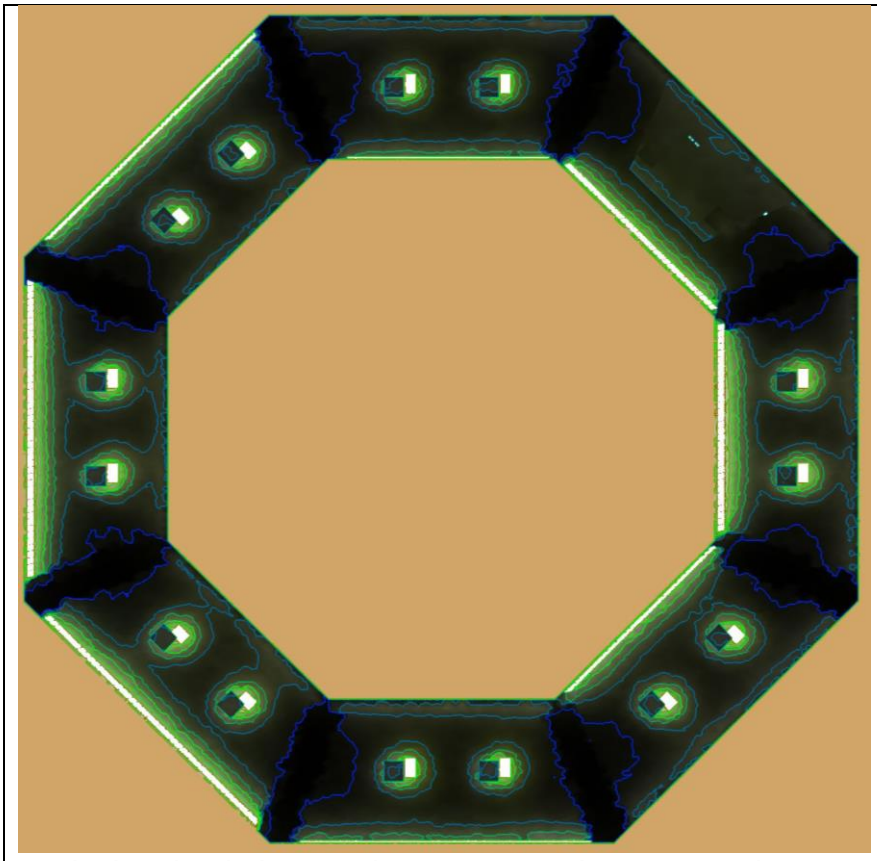
Table 6, Typical-1 daylight analysis



Typical-2 layout indicating Regularly and Non-Regularly occupied space



Typical-2 simulation result – 21 September @ 0900 hrs.



Typical-2 simulation result – 21 September @ 1500 hrs.

Floor	Reg. Occupied Area (Sq.m)	% receiving (300 - 3000 lux) @ 0900 hrs.	% receiving (300 – 3000 lux) @ 1500 hrs.	Avg. minimum Daylight Area (Sq.m)
Typical-2	36468	98.79	98.59	35990

Table 7, Typical-2 daylight analysis

Floor	Regularly occupied area (Sq.m)	% receiving (300 – 3000 lux) @ 0900 hrs.		Daylight Area		Avg. minimum Daylight Area (Sq.m)
		0900	1500	0900	1500	
Ground	19280	97.59	97.45	18815	18789	18802
Typical-1	50610	97.72	98.83	49458	50016	49737
Typical-2	36468	98.79	98.59	36028	35952	35990
Total						
% area receiving 300 lux – 3000 lux						

Table 8, Daylight analysis summary

On analysis it is observed, that the project achieves the credit requirement by 90% of regularly occupied areas with daylighting by achieving the required daylight illuminance level between 300 lux – 3000 lux. The minimum percentage of regularly occupied area in each floor achieving the prescribed illuminance is 97.45%. Hence, the project achieves additional 3 points under Indoor Environmental Quality (EQ) credit : Daylight.

THERMAL COMFORT

Thermal comfort is the condition of mind that expresses satisfaction with the surrounding thermal environment. This is said to be a well-balanced combination of building systems adapted to both the location of the building as well as the type of activity performed within the building. This section briefs about thermal comfort achieved in compliance with ASHRAE 55-2017.

Here the first thing to be consider while designing is the building envelop, for this building materials were been carefully selected to obtain u-value of wall envelop within 0.4, roof to be within 0.3, glass to be within 3.3 and the window wall ratio to be within 40% as stated by ECBC for warm-humid climatic zone. We have achieved more than what is recommended by ECBC through material section to reduce the heat gain into the space. External wall is of 350mm with u-value – 0.15 (cement plaster/AAC Block/cement mortar/Fly-Ash Brick/ cement plaster), internal wall is of 238mm with u-value – 0.34 (cement plaster/Fly-Ash Brick/ cement plaster), Saint globin double glazed unit with u-value 2.7 (double glazing unit has an air gap in between which is been filled with argon gas for reduce the heat gain into the space)... all these materials constitute the building envelop and more over all these materials have the recycled content in it, which reduces the embodied carbon associated with the material.

Efficiency Parameters	ECBC Baseline Metrics	Design Considerations
U-value of wall (W/sq.m - °C)	0.4	0.15
U-value of roof (W/sq.m - °C)	0.3	0.3
U-value of glass (W/sq.m - °C)	3.3	2.7
Max. Window Wall Ratio (WWR)	40%	40%

+ Materials were been selected based on thermal performance, low embodied carbon and its compliance to LEED v4.1

Table 9, Representing u-value of envelope

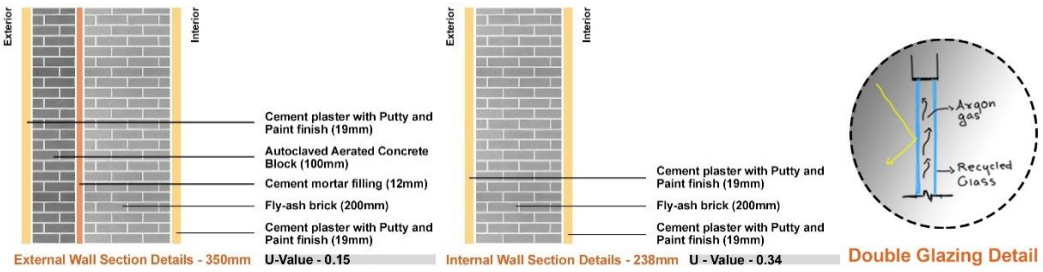


Figure 39, Wall envelope section detail

For all the exposed roof surfaces earthen pot insulation is been done, principle is that air cavity between two layers acts as a barrier to heat transfer, in this method inverted pots are laid on the roof and the space between them is filled with plain cement concrete and it is finished with material of higher SRI value.

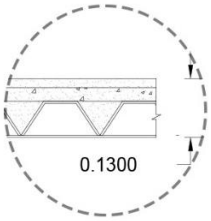


Figure 40, Earthen pot insulation detail

Shading devices plays a major role in reducing the heat gain into the space, since the building form faces all the eight coordinal direction, the designing of shading device includes all the three types of external shading devices horizontal, vertical and egg-crate are used. Before starting up with the shading devices critical times for shading were identified through sun-path diagram. Next to that selection of shading devices were been done, such that northern and southern façade is been shaded with horizontal shading device, since sun is at higher angle during this phase, eastern and western facades are shaded with vertical shading device, since sun is at lower angle during this phase, all other directions NE,SE,SW,NW are shaded with egg crate shading device. Wooden shading devices of size 1800 mm x 100 mm x 20 mm are used, with varying c/c in accordance to the orientation and external view were been adopted. Here the daylight shelves also act as

catwalk space for services. The efficiency of shading devices is analyzed through ecotect, which states that shaded wall has 1/5th the amount of solar radiation than on a non-shaded area of wall, this is highly beneficial to reduce the solar heat gain.

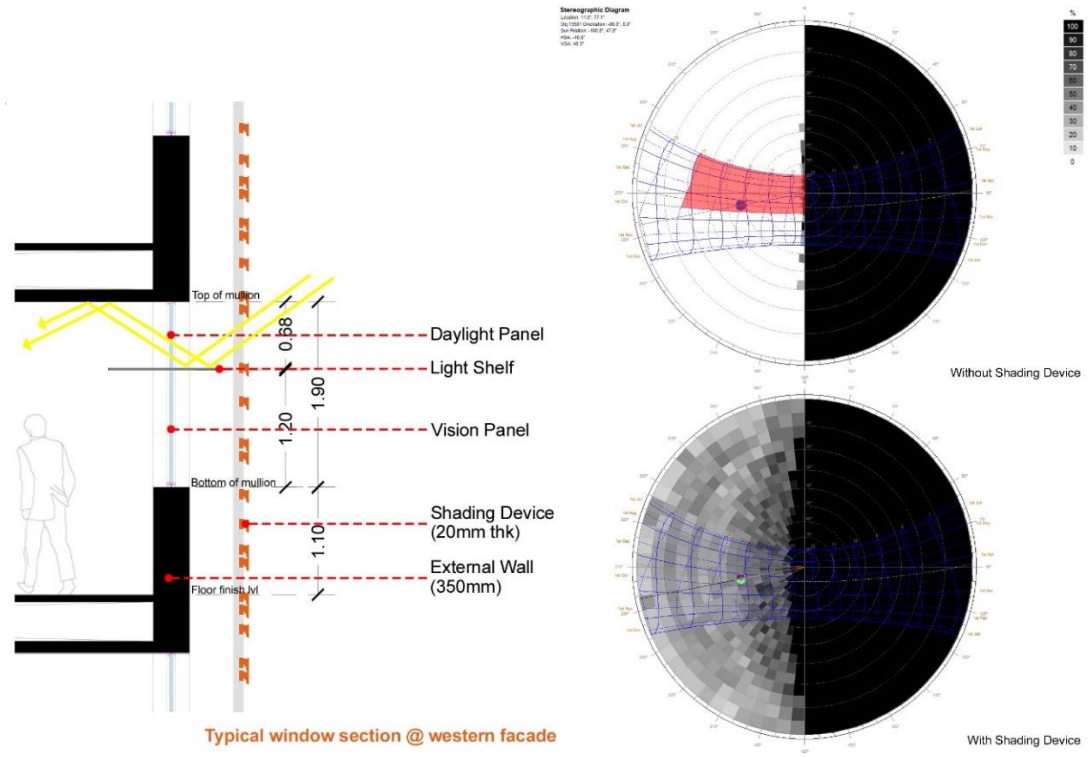


Figure 41, Typical wall section and shadow analysis western facade

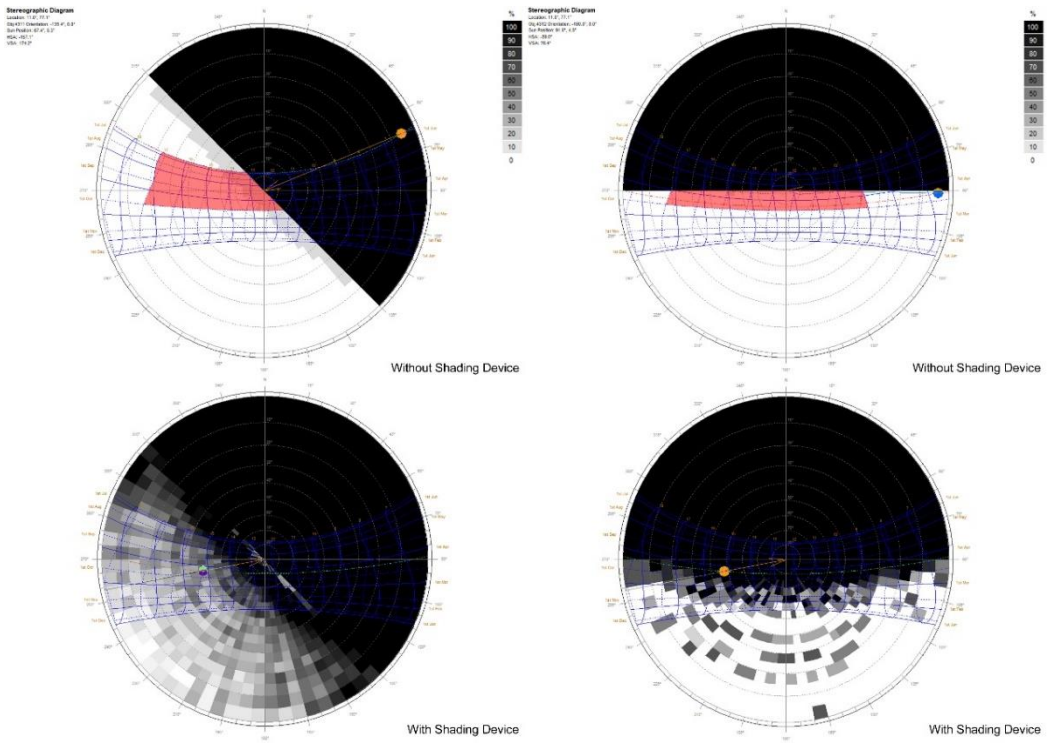


Figure 42, Shadow analysis south-western facade and southern facade

Solar chimney is been used to suck out the hot air inside the space, this solar chimney is been placed at the center of all the eight zones and the principle used is stack effect, such that top of solar chimney is been painted dark this ensures heating up that particular space quickly which induces convention so that hot air from inside the building space is been sucked out much quicker in a passive way.

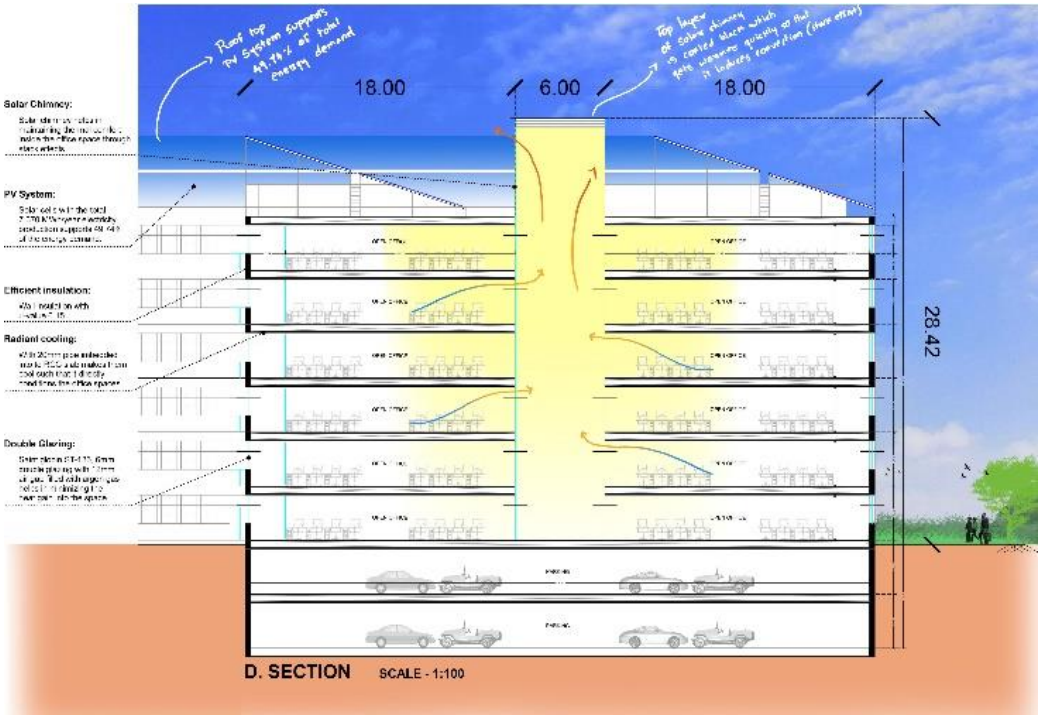


Figure 43, Typical section over solar chimney

Instead of using conventional air conditioners which consumes more energy and recirculates the air, here we are using elevated air speed to achieve thermal comfort as stated by ASHRAE 55-2017, which not only reduces the energy needed for air conditioning the space but also circulates only the fresh air inside the space through triple filtering. This method satisfies the thermal comfort need for 85% of days in a year, remaining 15% of the days thermal comfort is achieved through radiant cooling system for this purpose gases produced through biogas system is been utilized so that the carbon emission for this is lesser than the conventional means. To evaluate the same ‘CBE Thermal Comfort Tool by Berkeley University of California’ is used, which states that this system satisfies the ASHRAE 55-2017.

Figure 44, CBE thermal comfort result

NET ZERO ENERGY

A net zero energy means that total amount of energy used by the building on an annual basis is equal to that of renewable energy generated on-site or procured off-site. This is in compliance with LEED Zero Energy : Energy Balance for the purpose of evaluation. The simple formula for evaluating is

Source energy balance = Total energy consumed – Total energy Generated on-site or Procured off-site

If the balance is ≤ 0, then the project is compliance with LEED Zero Energy

Here all the solar planes are tilted 18° towards south for efficient energy generation and the wet and dry cleaning is done once in 15 days, the cleaning water also goes back to vegetation so that there won't be any water waste.

First and foremost, step to achieve this is to evaluate the energy demand on annual basis, here we have calculated the energy demand using the average value for office building stated by BEE for warm-humid climatic zone (40 W/Sq.m). The annual energy demand is 13,570.75 Mwh/Yr and this demand will be tackled by on site renewable energy generation of 17,234 Mwh/Yr, through solar power plant (9,864 Mwh/Yr) and main building rooftop (7,370 Mwh/yr). Through simulation and evaluation, the results show that it is in compliance with LEED Zero Energy and provides the surplus energy generation of 3,663.25 Mwh/Yr to the electric grid.

PVSYST V6.70	Towards Zero | Milieu Design Solution	06/04/20	Page 1/1

Main Building

Grid system presizing

Geographical Site	**Coimbatore**		Country	**India**
Situation	Latitude	11.03° N	Longitude	76.96° E
Time defined as	Legal Time	Time zone UT+5.5	Altitude	0 m
Collector Plane Orientation	Tilt	18°	Azimuth	0°

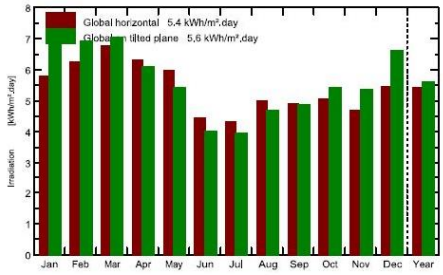
PV-field installation main features

Module type	Standard
Technology	Monocrystalline cells
Mounting method	Flat roof
Back ventilation properties	Ventilated

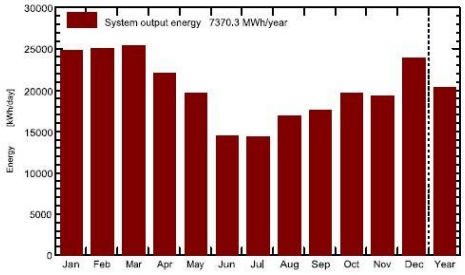
System characteristics and pre-sizing evaluation

PV-field nominal power (STC)	Pnom	4304 kWp		
Collector area	Acoll	26900 m²		
Annual energy yield	Eyear	7370 MWh	Specific yield	1712 kWh/kWp
Economic gross evaluation	Investment	*74990 INR	Energy price	7.43 INR/kWh

Meteo and incident energy



System output



	Gl. horiz. kWh/m².day	Coll. Plane kWh/m².day	System output kWh/day	System output kWh
Jan.	5,76	6,83	24700	765709
Feb.	6,21	6,92	25028	700787
Mar.	6,76	7,04	25447	788869
Apr.	6,32	6,08	21989	659681
May	5,96	5,42	19588	607214
June	4,44	4,00	14456	433693
July	4,32	3,92	14182	439651
Aug.	4,97	4,67	16906	524096
Sep.	4,88	4,86	17586	527585
Oct.	5,05	5,41	19573	606770
Nov.	4,69	5,34	19300	579006
Dec.	5,47	6,57	23782	737227
Year	5,40	5,58	20193	7370289

Figure 45, Solar power generation on main building rooftop

PVSYST V6.70	Towards Zero | Milieu Design Solution	06/04/20	Page 1/1

Solar Plant

Grid system presizing

Geographical Site	**Coimbatore**			Country	**India**
Situation		Latitude	11.03° N	Longitude	76.96° E
Time defined as		Legal Time	Time zone UT+5.5	Altitude	0 m
Collector Plane Orientation		Tilt	18°	Azimuth	0°

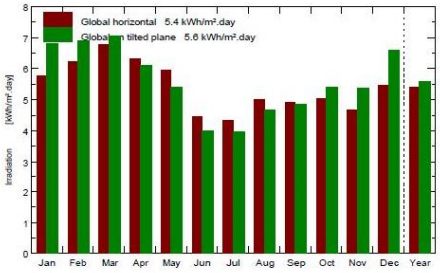
PV-field installation main features

Module type	Standard
Technology	Monocrystalline cells
Mounting method	Ground based
Back ventilation properties	Ventilated

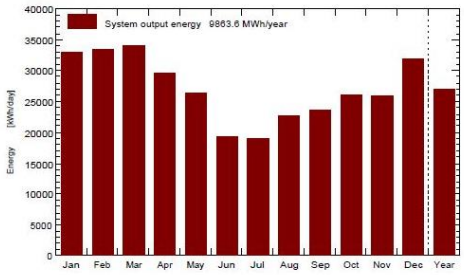
System characteristics and pre-sizing evaluation

PV-field nominal power (STC)	Pnom	5760 kWp			
Collector area	Acoll	36000 m²			
Annual energy yield	Eyear	9864 MWh	Specific yield	1712	kWh/kWp
Economic gross evaluation	Investment	*99244 INR	Energy price	7.13	INR/kWh

Meteo and incident energy



System output



	Gl. horiz. kWh/m².day	Coll. Plane kWh/m².day	System output kWh/day	System output kWh
Jan.	5.76	6.83	33056	1024741
Feb.	6.21	6.92	33495	937856
Mar.	6.76	7.04	34056	1055735
Apr.	6.32	6.08	29428	882845
May	5.96	5.42	26214	812629
June	4.44	4.00	19347	580407
July	4.32	3.92	18980	588381
Aug.	4.97	4.67	22626	701393
Sep.	4.88	4.86	23535	706062
Oct.	5.05	5.41	26195	812034
Nov.	4.69	5.34	25829	774878
Dec.	5.47	6.57	31827	986624
Year	5.40	5.58	27024	9863584

Figure 46, Solar power generation plant

Category	Calculation
ENERGY CONSUMED	
Renewable energy generated and used on site	13,570.75 Mwh
Electricity drawn from grid	-
Other Source	-
Total Source Energy Consumed (a)	**13,570.75 Mwh**
ENERGY GENERATED	
Renewable energy generated and used on site	13,570.75 Mwh
Onsite generated electricity exported to grid	3,663.25 Mwh
Offsite renewable energy added to an electric grid	-
Total Source Energy Generated (b)	**17,234 Mwh**
Source Energy Balance (a-b)	**-3,663.25 Mwh**

Table 10, Net zero energy evaluation

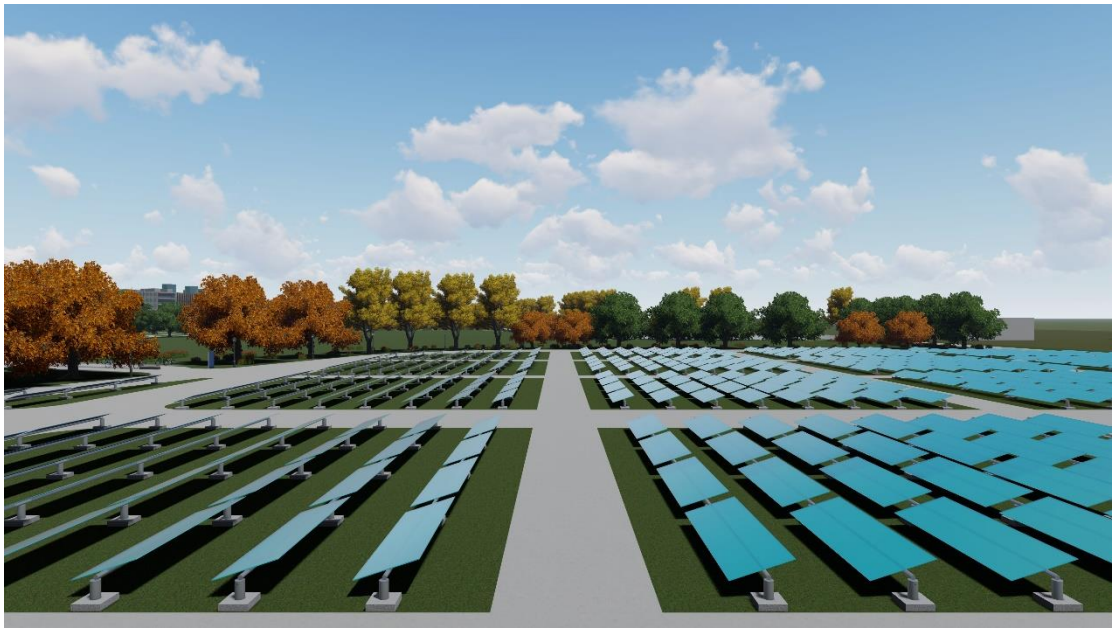


Figure 47, Solar power plant (visualization)

CARBON NEUTRALITY

A carbon neutrality or zero carbon footprint, refers to achieving net zero carbon dioxide emissions by balancing carbon emissions with carbon removal or by eliminating carbon emissions. This is in compliance with LEED Zero Carbon : Carbon Balance for the purpose of evaluation. The simple formula for evaluating is

Carbon balance = Total carbon caused – Total carbon avoided

If the balance is ≤ 0, then the project is compliance with LEED Zero Carbon

Here we have calculated the carbon balance in terms of Towards Zero requirement, which is far more effective means for achieving actual carbon balance than the LEED Zero Carbon. Major changes from LEED Zero Carbon is adding of embodied carbon emission associated with construction.

Now let's look into the consideration take up during the calculation of embodied carbon emission associated with construction, entire campus is been taken up for calculation including all the buildings, pavement area, excavation work during construction... except the internal spaces such as cabins, meeting rooms... are not considered for calculation, here global warming potential of Co_2 for building materials are taken from 'Indian construction materials database on embodied energy and global warming potential methodology report – 2017' by IFC and European union, carbon emission by renewable energy generated and used on site is considered zero as stated by LEED Zero Carbon and Towards Zero, carbon emission through natural gas is considered for bio-gas system used on site for cooking and radiant cooling system is considered for 260 working days, carbon emission through vehicles are considered for 260 working days with 2 way trip for employees and one way trip for visitors, the vehicle routes are calculated based on the study on surrounding Tech parks.

Route name	Distance (km)	No of motorcycle	Motorcycle carbon emi.	No of car pool	Car pool carbon emi.	No of car (solo)	Car (solo) carbon emi.	No of bus	Bus carbon emi.
Cms	6.3	96	44	58	40	14	24	11	13
Gandhipuram	9.6	96	67	58	60	14	36	11	21
Sivanandha colony	11	105	84	86	104	22	62	9	19
Central studio	14	105	107	86	132	22	79	9	25
Irugur pirivu	14	105	107	86	132	22	79	9	25
Kanuvai	14.5	105	110	86	137	22	81	10	27
Sungam	14.9	105	114	86	140	22	84	10	27
Sundakkamuthur	19.5	79	111	216	459	54	274	9	32
Annur	20	79	114	216	471	54	281	9	33
Kalampalayam	22			58	138	14	82	7	29
Kalikkanaichenpalayam	22			58	138	14	82	7	29
Sulur	22.4			58	141	14	84	7	30

Route name	Distance (km)	No of motorcycle	Motorcycle carbon emi.	No of car pool	Car pool carbon emi.	No of car (solo)	Car (solo) carbon emi.	No of bus	Bus carbon emi.
Thondamuthur	26.2			101	288	25	172	5	25
Karumathampatti	27			101	297	25	177	5	26
Mettupalayam	31			58	195	14	116	5	27
Kinathukadavu	36.2			29	114	7	68	2	13
Annual carbon			**446182**		**1552370**		**924809**		**208154**

Table 11, Carbon emission through vehicles (employees)

S.No	Description	Volume (cu.m)	Kg Co2 eq.	Total embodied carbon
1	Earthwork excavation	208140	0.71	147779
	Excavation footing	2058	0.71	1461
2	Concrete footing	2058	0.084	173
3	Column base	76	0.084	6
	Column stem	2322	0.084	195
4	Beam	30325	0.084	2547
5	Top slab	36688	0.084	3082
	Bottom slab	24458	0.084	2055
	Tile finish	1223	0.67	819
	Tile adhesive	734	0.47	345
	Cement screed ceiling finish	1223	0.18	220
6	External wall-1			
	Cement plaster (19mm)	647	0.44	285
	Cement mortar (12mm)	204	0.14	29
	AAC block (100mm)	1703	0.175	298
	Flyash brick (200mm)	3407	0.11	375
	Glazing (24mm)	31	0.84	26
	External wall-2			
	Cement plaster (19mm)	419	0.44	185
	Cement mortar (12mm)	132	0.14	19
	AAC block (100mm)	1104	0.175	193

	Flyash brick (200mm)	2207	0.11	243
	Glazing (24mm)	22	0.84	18
	Internal wall-1			
	Cement plaster (19mm)	854	0.44	376
	Flyash brick (200mm)	4493	0.11	494
	Internal wall-2			
	Cement plaster (19mm)	295	0.44	130
	Flyash brick (200mm)	1555	0.11	171
	Core			
	Glazing (24mm)	258	0.84	217
	Internal wall-B1			
	Cement plaster (19mm)	58	0.44	26
	Flyash brick (200mm)	614	0.11	68
	Internal wall-B2			
	Cement plaster (19mm)	47	0.44	21
	Flyash brick (200mm)	499	0.11	55
	Internal wall-B3			
	Cement plaster (19mm)	55	0.44	24
	Flyash brick (200mm)	576	0.11	63
Total embodied carbon				**161997**

Table 12, Embodied carbon in main building

Item	Category	Calculation (kg Co_2e)
Carbon caused		
Energy consumption	Renewable energy generated and used on site	0
	Electricity drawn from grid	-
	Natural gas	70571
	Other	-
Transportation	Walk, bike...	0
	Motorcycle	446182
	2-3 carpool	1552370
	Alternative fuel vehicles	-
	Bus	208154
	Car (solo)	924809
	Visitors	417994
Embodied carbon	Embodied carbon associated with construction	310933
Total carbon caused (a)		**3931012**
Carbon avoided		
Onsite generated electricity exported to grid	Electricity	3663250
Offsite renewable energy added to an electric grid	Offsite renewable energy	-
	EACs	-
	Carbon offsets	-
Total carbon avoided (b)		**3663250**
Carbon balance		
Carbon balance (a-b)		**267762**

Table 13, Carbon balance evaluation

Through calculation and evaluation, the results show that it is in compliance with LEED Zero Carbon and Towards Zero. This is possible by reduction in carbon emission right from the material selection, parking space allocation, alternative energies used on site and providing of surplus renewable energy to the grid helps in achieving carbon balance/ carbon neutrality in 6 years and 16

days, during the later on coming years this campus is said to be carbon negative. We strongly believe that even though if we have considered the internal spaces for calculation, carbon neutrality can be achieved within 10 years from the date completion of the project.

ZERO WATER BALANCE

Water is the main constituent of earths hydrosphere and the fluids of most living organisms; it is vital for all known forms of life. A zero-water balance means that total portable water consumed to be balanced through any other alternative water used and/ or water returned. This is in compliance with LEED Zero Water : Water Balance for the purpose of evaluation. Simple formula for evaluating is

Water Balance = Total Potable Water Consumed – (Total Alternative Water Used + Water Returned to Original Source)

If the balance is $\leq$ 0, then the project is compliance with LEED Zero Water.

The First and foremost thing is to collect data regarding the site and climate (refer site description) and the annual demand to accommodate 15,000 employees, which is 180,000 cu.m determined using IS 1172 : 1993 / NBC clause 4.1.2 (45 ltr/ person – 25 ltr domestic + 20 ltr flushing). Through efficient water fixtures the total portable water demand can be reduced 30% - 40%, which brings the portable water demand to 117,000 cu.m (35% reduction). Annual rainfall catchment is 126465.9 cu.m, calculated through the surface runoff coefficient (0.95 – cemented / tiled roof, 0.95 – concrete pavement, 0.3 – mixed vegetation), which is captured through water reservoir over the low-lying area of the site at 7m depth.

Here the rainwater collected are connected to Sewell which is connected to water reservoir, this acts as rainwater catchment point and along the way of Sewell reedbeds are planted this reduces the contamination getting collected in catchment point.

We strongly believe that within two to three years we can see a gradual change in ground water level across the surrounding area of this region.

Through evaluation it is shows that the project is in compliance with LEED Zero Water : Water Balance, with surplus water of 84465.9 cu.m and this can be utilized for neighborhood needs or to recharge the ground water.

Category	Description	Calculation
POTABLE WATER CONSUMED		
Water consumption	Potable water consumed by project	117000 cu.m
	Water consumed by vegetation	55744.68 cu.m
Total potable water consumed (a)		**172744.68 cu.m**
ALTERNATIVE WATER SOURCES & WATER RETURNED		
Off-site water sources	Reclaimed water delivered from municipality	-
	Other off-site sources	-
On-site water sources	Captured stormwater runoff (cemented / tiled roof)	30458.3 cu.m
	Captured stormwater runoff (concrete pavement)	35504.15 cu.m
	Captured stormwater runoff (mixed vegetation)	60503.44 cu.m
	Greywater reuse	75000 cu.m
Total alternative water sources + water returned (b)		**201465.9 cu.m**
WATER BALANCE		
Water balance (a-b)		**-28721.22 cu.m**

Table 14, Zero water balance evaluation

Figure 48, Water reservoir (visualization)

ZERO WASTE DISCHARGE

Zero waste is a goal that is ethical, economical, efficient and visionary, to guide people in changing their lifestyle and practices to emulate sustainable natural cycles, where all discarded materials are designed to become resources for other to use. For evaluating this, LEED Zero Waste recommends to achieve platinum rating in TRUE Zero Waste rating system. There are many strategies involved to achieve zero waste, starting from reduction, labeling, employee catalogue, waste processing, etc., Here waste management start from the campus entrance itself such that one-time use plastics are restricted inside the campus, all the products brought into the campus including the package is evaluated by waste management team so that right vendor is choose around the local so that waste is reduced and a contract/ agreement is signed with all the regular vendors to make sure of minimized waste generation or to get back the waste product by the vendor for recycling them. Later on periodic trainings and events will be conducted by the office for all the employees around the weekends to know about the zero waste program implemented by the office, which gives knowledge about the same to all the

employees for contributing in the zero waste program and there is an reuse display area at the campus which ensure the minimum diversion to treatment plants, this is accessible by public also so that it encourages zero waste generation at neighborhood level. Waste processing flow chart is provided below

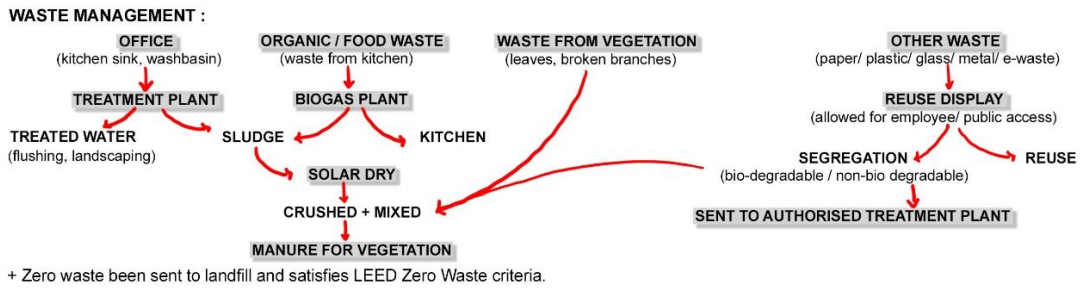


Figure 49, Waste management chart

Treatment Plant	Type of Waste
Green Bhoomi	Plastic/ Paper/ Glass
Green Era Recyclers	E-Waste

Table 15, List of waste treatment plant

Points Achieved	Category	Total Points
4	Redesign	4
7	Reduce	7
6	Reuse	7
6	Compost (Re-earth)	7
3	Recycle	3
4	Zero waste reporting	4
5	Diversion (min 90%)	5
5	Zero waste purchasing	9
6	Leadership	6
8	Training	8
3	Zero waste analysis	5
4	Upstream management	4

4	Hazardous waste prevention	5
3	Closed loop system	4
3	Innovation	3
71	**Total**	**81**

Table 16, True zero waste rating system check list

True Zero Waste rating system check list ensures that it achieves platinum rating, this means it is in compliance with the LEED Zero Waste.

PRODUCTIVE LANDSCAPE

A combination of concern over healthier diets and embodied carbon over the food products lets to the inclusion of productive landscape in current scenario. Here the considerations taken up during the selection of landscape species are

Native species with more preference to drought tolerant and endangered species along with productivity (fruits, vegetables...). later on, this list is then shorted out with eye caching color of that species which is chosen in relation to induce the employee's mode such that it also increases the productivity.

Some of the species chosen for the productive landscaping are listed below

Species	Color	No. of species	Annual Irrigation (cu.m)
Bilimbi	Green	54	127.8
Cassia Fistula	Yellow	237	259.6
Chakotra	Green	56	61.8
Champaka	Green	50	54.2
Curry tree	Green	48	156.1
Gooseberry	Yellow	257	281.3
Guava	Green	75	82.4
Indian bael	Green	65	71.5
Indian fig	Green	62	102.4

Jackfruit	Green	51	56.4
Jamun	Green	69	75.9
Jungle jalebi	Green	58	64
Karonda	Pink	183	100.1
Khirni	Green	67	73.7
Mango	Green	77	84.6
Mangosteen	Green	58	64
Mulberry	Green	71	117.1
Phalsa	Green	52	57.5
Pomegranate	Green	73	171.9
Rambutan	Red	206	483.8
Total		**1873**	**2545.9**

Table 17, Productive landscape species

The species planted are not monotonous although the majority of the dominant color code of the species is represented below

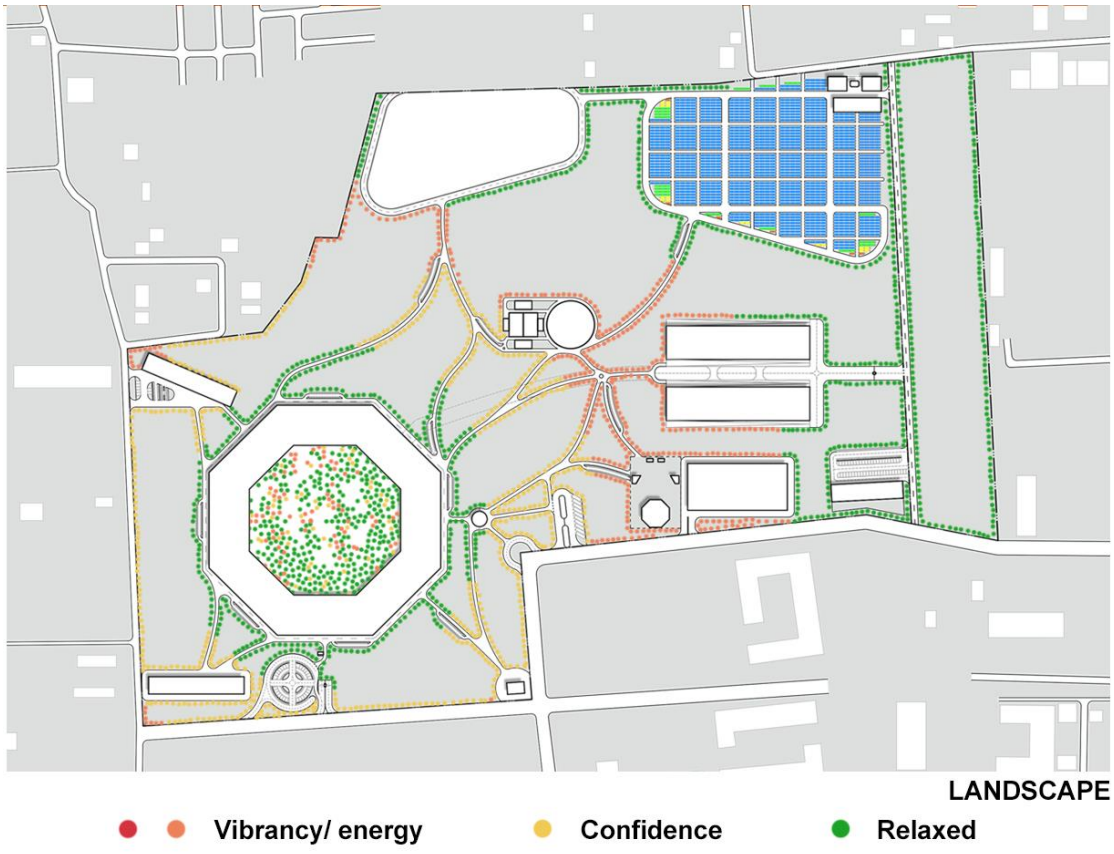


Figure 50, Productive landscaping – site plan

In addition to productive landscaping species, crops were also been cultivated on the balance area of the site (48.52 acres) which

satisfies the need for 15% of the annual demand for food preparation. All the cultivated species are native and they stated below

Species	Annual Demand (Kg)	Annual On-site Yield (Kg)	Availability
Coconut	22750	22750	Available
Coriaander Seed/ Leaves	9100	9100	Available
Garlic	9100	4590	6 months
Ginger	13650	500	1 month
Ground nut	27300	13650	6 months
Horse gram	54600	54600	Available
Onion	136500	34720	3 months
Ragi	81900	81900	Available
Rice	136500	136500	Available
Snake gourd	54600	54600	Available
Spinach	91000	91000	Available
Turmeric	19110	19110	Available
Urad dal	27300	13652	6 months

Table 18, Crops cultivated and availability

Month	Area of cultivation (acre)	Total irrigation
Jan	44.9	5180.39
Feb	31.2	2955.6
Mar	28.2	2653.73
Apr	45.6	4889.32
May	45.6	4889.32
Jun	45.6	4889.32
Jul	35.2	3172.17
Aug	48.1	4809.23
Sept	48.1	4809.23
Oct	48.1	4809.23
Nov	46.9	4960.85
Dec	44.9	5180.39
Annual irrigation		**53198.78**

Table 19, Crops cultivated and irrigation

CONCLUSION

CONCLUSION

The final design “Towards Zero | Milieu Design Solution (IT Park)” demonstrates that the concept of Towards Zero is more efficient that Net Zero and can be implemented in current scenario. The main objective of minimizing the environmental impacts are achieved by reduction in footprint, choosing of right building materials and reduced parking space, which encourages public transportation, car pool... while permitting good permeability for ease of access by pedestrians and cyclist also encourages healthy exercise.

Through ‘Data Analysis’, its clear that the project satisfies all the requirement by LEED Zero for achieving Net Zero in all the four categories (carbon balance, energy balance, water balance and waste discharge).

It creates a new way of approach for building design and guide the occupants in changing their lifestyle and practices to emulate sustainable natural cycles.

Thank You

Hoping for a sustainable built environment ahead.

APPENDIX - 1

Equation 1. Annual Co2e from electricity consumption

Annual Co_2e from electricity consumption = annual electricity consumption (Kwh) x grid coefficient for the location (Kg Co_2e/ Kwh)

Equation 2. Annual Co2e from fuel consumption

Annual Co_2e from fuel = annual fuel consumption (Cu.m) x carbon emission factor for the fuel (Kg Co_2e/ Cu.m)

Equation 3. Annual Co2e from transportation

Values calculated are to take from the occupant transportation survey conducted at least once in a year.

Co2e for route = (Kg Co2e/ Km) x distance traveled in Km

Mode	Kg Co2e/ Km
Walk, bike	0
Motorcycle	0.07
Heavy rail	0.09
2-3 carpool	0.11
Light rail	0.12
Alternative fuel vehicle	0.12
Bus	0.19
Car (solo)	0.26

Table 20, Co2e value for a one-way trip (source – LEED Zero)

Equation 4. Embodied carbon associated with construction

Co2e of material = volume of building material (m3) x density of building material (Kg/ m3) x embodied carbon emission (Kg Co2/ Kg)

Equation 5. Annual carbon avoided from onsite generated electricity

Annual Co_2e avoided from onsite electricity generated = annual electricity generated from on-site renewable source (Kwh) x hourly carbon emission rates for the recipient grid (Kg Co_2e/ Kwh)

Equation 6. Annual carbon avoided from offsite generated electricity

Annual Co_2e avoided from offsite electricity generated = annual electricity generated from off-site renewable source (Kwh) x hourly carbon emission rates for the recipient grid (Kg Co_2e/ Kwh)

Equation 7. Annual carbon avoided from purchase of EACs

Annual Co_2e avoided from purchase of EACs = annual electricity generated represented by EAC purchase (Kwh) x hourly carbon emission rates for the recipient grid (Kg Co_2e/ Kwh)

Item	Category	Calculation (kg Co_2e)
Carbon caused		
Energy consumption	Renewable energy generated and used on site	0
	Electricity drawn from grid	Equation 1
	Natural gas	Equation 2
	Propane	
	Diesel oil	
	Other	
Transportation	Walk, bike...	0
	Motorcycle	Equation 3
	2-3 carpool	
	Alternative fuel vehicles	
	Bus	
	Car (solo)	
	Light rail	
	Heavy rail	
Embodied carbon	Embodied carbon associated with construction	Equation 4
Total carbon caused (a)		**Sum = carbon from energy + transportation + embodied carbon**

Carbon avoided		
Onsite generated electricity exported to grid	Electricity	Equation 5
Offsite renewable energy added to an electric grid	Offsite renewable energy	Equation 6
	EACs	Equation 7
	Carbon offsets	Sum Co2e for carbon offsets purchase
Total carbon avoided (b)		**Sum = onsite + offsite**
Carbon balance		
Carbon balance (a-b)		**Difference = (a) – (b)**

Table 21, Overview of carbon balance table

APPENDIX – 2

Category	Calculation
ENERGY CONSUMED	
Renewable energy generated and used on site	Documented data
Electricity drawn from grid	
Natural gas	
Propane	
Diesel oil	
Other	
Total Source Energy Consumed (a)	**Sum = energy consumed**
ENERGY GENERATED	
Renewable energy generated and used on site	Documented data
Onsite generated electricity exported to grid	
Offsite renewable energy added to an electric grid	
Total Source Energy Generated (b)	**Sum = onsite + offsite**
Source Energy Balance (a-b)	**Difference = (a) – (b)**

Table 22, Overview of energy balance table

APPENDIX – 3

Equation 1. Annual surface runoff volume

Runoff volume = surface area (Sq.m) x runoff coefficient x average annual rainfall (m)

Surface type	Runoff coefficient
Cemented/ Tiled roof	0.95
Roof garden	0.5 – 0.1
Turf, Flat to steep	0.25 – 0.45
Mixed vegetation, Flat to steep	0.1 – 0.3
Concrete Pavement	0.95
Gravel Pavement	0.75
Open-grid Grass Pavement	0.5
Water bodies (lined) eg. Swimming pool	0.95
Water bodies (un-lined) eg. Harvesting pond	0

Table 23, Runoff coefficient for typical surface type

Category	Description
POTABLE WATER CONSUMED	
Water consumption	Potable water consumed by project
Total potable water consumed (a)	
ALTERNATIVE WATER SOURCES & WATER RETURNED	
Off-site water sources	Reclaimed water delivered from municipality
	Other off-site sources
On-site water sources	Captured rainwater (roof)
	Captured stormwater runoff (site)
	AHU Condensate
	Steam recovery
	Greywater reuse
	Other on-site water source
Water returned	Water collected from building systems (e.g. onsite treated

	wastewater and returned to original source)
Total alternative water sources + water returned (b)	**Sum = onsite + offsite + returned**
WATER BALANCE	
Water balance (a-b)	**Difference = (a) + (b)**

Table 24, Overview of water balance table

REFERENCE

Alexandra Paio (2014) ‘generative form’, Parametric Urban Models based on Feri Otto’s Generative Form Finding Processes pp. 2-11

ANSI (2017) ‘thermal comfort’, ASHRAE Standard 55-2017 (Thermal Environmental Conditions for Human Occupancy), pp. 4-14

ASHRAE (2010) ‘indoor air quality’, ASHRAE Standard 62.1-2010, pp. 5-20

ASHRAE (2016) ‘performance cost index’, ASHRAE Standard 90.1-2016, pp. 298-338

ASHRAE (2017) ‘thermal comfort’, ASHRAE Standard 55-2017, pp. 9-12

Babak Raji (2017) ‘form optimization’, Early stage design consideration for energy efficiency of office buildings, article – MDPI pp. 14-19

BEE (2016), ‘material standards’, Energy Conservation Building Code – 2016, pp. 15-21

BEE (2018) ‘Building Envelope – thermal calculation’, Eco-Niwas Samhita – 2018, pp. 22-26

BIS (2016), ‘national standards’, National Building Code of India, Volume – 1&2

Central Ground Water Board (2008) ‘groundwater level’, District Groundwater Brochure Coimbatore District, pp. 16-22

CPWD (2013) ‘office buildings guideline’, A Handbook of Planning of Office Buildings pp. 13-74

Department of Environment-Govt. of India ‘Endemic Flora’, Database on Endemic Flora of TamilNadu, pp. 2-23

Earthen pots insulation system : Thermal comfort design. http://mansi-shah.weebly.com

Edwards T. White (1982) ‘site analysis’, Site Analysis, pp. 9-123

Energies (2011), ‘carbon footprint’, Carbon Footprint of an Office Building, pp. 2-12

Gandhimathi .A (2010) ‘foundation depth’, Spatial Analysis of Soil in Coimbatore, pp. 2987-2995

GHG Platform India (2017) ‘greenhouse gas emission report’, GHG emissions in India, pp. 1-7

Gov. TamilNadu (2019), ‘DCR Norms’, TamilNadu Combined Development and Building Rules, pp. 50-65, 108, 111, 112, 122, 224 – 236

Hassanean S.H. Jassim (2017) ‘Co2e from excavators in earthwork operation’, Predicting energy consumption and co2 emissions of excavators in earthwork operations, pp. 3-5

Hoong yong wen (2017) ‘Circulation network and efficiency’, Architecture x Movement: How human circulation network can shape the workspace, pp. 9-21

IFC (2017) ‘global warming potential for construction material’, Indian construction materials database of embodied energy and global warming potential methodology report, pp. 67-69

IGBC (2016) ‘IGBC rating system’, IGBC Green New Building Rating System, pp. 16-137

IGBC (2018) ‘rainwater conservation’, IGBC Indian Green League – 2018 Water Conservation, pp. 4-6

IPCC (2017) ‘embodied energy and building material’, IPCC report – 2017, pp. 693,694

IPCC (2014) ‘climate change and impact’, IPCC climate change – synthesis report 2014, pp. 39-73

Kamaljit Singh (2019) ‘self-cooling design’, architectural design of smart ventilation and drainage systems in termite nest, pp. 3-7

Kaufman A.J (2004) ‘emotional and physiological response to landscape’, Horticulture, Human Well-Being and Life Quality, pp. 229-233

Leah Burrows (2019) ‘termite mound shape’, How termite mound gets their shape, article – Harvard school of engineering and applied science.

National crime prevention council – Singapore ‘crime prevention through design in office campus’, Crime prevention through environmental design, pp. 40-42

Shreya Kalpesh dalwadi (2018) ‘embodied carbon calculation’, Low carbon footprint urban and building design, pp. 3-7

Soil Survey and Land use Organization - Coimbatore (1972) ‘soil temperature’, Soils of Coimbatore District, pp. 3-12

UN Environment (2018) ‘global emission’, Emission Gap Report – 2018, pp. 5-19

USGBC (2020) ‘LEED rating system’, LEED v4.1 Building Design and Construction, pp. 8-169

USGBC (2019) ‘LEED zero’, LEED Zero Program Guide, pp. 2-12